UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(*THE NATIONAL FRUIT AND CIDER INSTITUTE*)

LONG ASHTON, BRISTOL,
1937.

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CONTENTS.

PAGE

INTRODUCTION .. .. *B. T. P. Barker, Director* 7

FRUIT CULTURE :—

Pear Breeding Investigations .. .. .. *G. T. Spinks* 15

Comparison of Pruning Treatments in Relation to Apple-Tree Shape—Progress Report .. .. .. *T. Swarbrick and W. E. Berry* 31

Notes on Some Methods of Staking and Guarding Orchard Trees and their Costs .. .. *T. Swarbrick* 57

PLANT PATHOLOGY :—

Combined Washes—Progress Report—IV. The Phytocidal Properties of Petroleum Oil Sprays alone and in Combination with Lime Sulphur .. .. *H. G. H. Kearns, R. W. Marsh and H. Martin* 65

The Control of Plum Sawfly (*Hoplocampa flava* L.) *H. G. H. Kearns and H. Martin* 78

The Origin of Infestation by the Oat Strain of the Eelworm *Anguillulina dipsaci* (Kühn) .. .. *C. L. Walton* 85

Tarsonemus spirifex (March), as an Oat Pest .. *C. L. Walton* 93

Progress Report on Vegetable Diseases—IX .. *L. Ogilvie and C. J. Hickman* 96

Cereal Diseases in the Bristol Province .. .. *L. Ogilvie* 110

The Effect of Fertilisers on Peas affected with "Pea Sickness"—Pot Experiments .. .. *L. Ogilvie, C. J. Hickman and C. L. Walton* 118

CIDER AND FRUIT PRODUCTS :—

Cider-Making Trials for the Season 1936-37 .. *P. T. H. Pickford* 127

The Cider Competitions Scheme, 1936-37. A New Feature. Awards for Fruit Condition .. .. .. *P. T. H. Pickford and G. T. Spinks* 155

CONTENTS—*contd.*

PAGE

CIDER AND FRUIT PRODUCTS ***(contd.)*** **:—**

Notes on Cider-Making Practices in Europe (1925-37) *Vernon L. S. Charley* 160

Investigations on Fruit Products.

XI. Experiments in Fruit Syrup Production .. .. *Vernon L. S. Charley* 170

XII. Chemical Constituents of Fresh Juices from Single Varieties of Soft Fruits, and the Suitability of the Juices for Syrup Manufacture. Progress Report II .. *Vernon L. S. Charley, R. C. Curtis and V. E. Sills* 186

XIII. The Commercial Production of Fruit Syrups—Season 1937 .. .. *Vernon L. S. Charley* 191

XIV. Experiments on the Production of Unfermented Apple Juice, 1934-38 .. *Vernon L. S. Charley* 195

Recent Developments in Fruit Products Research at Long Ashton .. .. *Vernon L. S. Charley* 231

WILLOW CULTURE :—

The Raising of Sets of the Cricket Bat Willow .. *H. P. Hutchinson* 243

SOIL SURVEYS :—

Soil Surveys. The Soils of the Teart Land Areas of Somerset. Progress Report No. II .. .. .. *D. A. Osmond* 250

ADVISORY AND EDUCATIONAL SECTION :—

Report on Advisory Work, 1936-37 258

PUBLICATIONS DURING 1937 291

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

Little alteration in the general position of the Department of Agriculture and Horticulture has occurred during the course of 1937. In respect of the progress of work and the financial position the observations made in the Introduction to the Annual Report for 1936 relating respectively to the three constituent centres of the Department—the Campden Research Station, the Berkeley Square Agricultural Advisory Centre and the Long Ashton Research Station—could be extended with little modification to cover the succeeding year also.

But, although actual changes in those respects materializing during the year have not been considerable, steps have been taken to review the organization and administration of the Department as a whole, especially in their relation to general University administration and responsibility. The present arrangements appear to call for revision owing to the varied developments of the activities of the respective centres since the existing system was first established. The matters concerned have been referred to an *ad hoc* Committee, consisting of representatives of the University, the Ministry of Agriculture and Fisheries, the Department of Scientific and Industrial Research, and the National Fruit and Cider Institute. Since the task of this Committee has not been completed yet, further reference to this subject can be deferred until the next Annual Report.

The death of the Rt. Hon. Henry Hobhouse, P.C., one of the Pro-Chancellors of the University, which took place in 1937, has removed one of the most prominent figures associated in the first place with the inception of the National Fruit and Cider Institute and, later, with the union of the Institute with the University. The Department in its present form is the offspring of that union. As Chairman of the original Governing Body of the Institute and, later—after its union with the University—of the joint Agricultural Committee of the University established in consequence, he played a most important part in shaping the policies which led to those developments and in enlisting the support necessary to bring them into effect. At this distance of time many may be unaware of the fact that it was mainly through his personal influence and interest that the capital sum of money required for the purchase of land, the buildings and equipment at the Long Ashton Research Station at the time of its association with the University in 1912 was obtained, he himself being one of the largest donors. Although during more recent years it became impossible for him to maintain the same active part in the Committee work associated with the Department his close interest in its activities continued to the end of his life.

The following sections review briefly the features of the year as far as the Berkeley Square Advisory Centre and the Long Ashton Research Station are concerned. Those relating to the Campden Research Station are contained in the Annual Report of that Station, now issued separately.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

The only staff change at this centre during the year has been the appointment of Mr. D. L. Smith, B.Sc., who was appointed during February as a temporary assistant in the chemistry department.

General.

The experiments in conjunction with the British Basic Slag Corporation, Ltd., in order to study the lime value of low-grade and high-grade basic slags on acid grassland, referred to in the Annual Report for 1936, have been initiated. The grant of the Corporation in aid of this work has been increased from £50 to £100 for a minimum period of two years.

The Bath and West Society has decided to support the investigations initiated by its Experiments and Education Committee on the nutritive value of hay produced under different conditions in the West Country by a grant of £100 per annum for the same period.

Considerable increase in the work of the Dairy Bacteriology Section has occurred. Towards this work the Worcester County Council has raised its grant from £75 to £100 per annum.

The offices and laboratories of the Centre were extensively repaired and redecorated during the first half of the year and the working conditions at Berkeley Square thereby considerably improved. Unfortunately on September 23rd, an outbreak of fire occurred in the Veterinary Laboratory, causing almost complete destruction of that section of the buildings and the fittings and equipment. The prompt action of the Bristol Fire Brigade succeeded in localising the outbreak to this quarter of the Centre and a more serious disaster was thereby averted. The damage was covered by insurance and the consequent repair and redecoration work has now been completed.

In consequence of the developments in the agricultural policy of the Government arising from considerations of national defence, in particular the Land Fertility Scheme which has brought problems relating to land fertility and soil conditions to the forefront, there have been increasing demands by farmers for specialized advice in those matters. A still larger increase is foreshadowed. Owing to the analytical and other laboratory work involved, arrangements designed to meet this additional pressure on the staff have been discussed with the County Agricultural Officers with a view to ensure the least possible delay in the despatch of reports of results and advice.

THE LONG ASHTON RESEARCH STATION.

Staff.

Although several staff changes have occurred during 1937 they have been limited chiefly to the more junior section of the staff. The Annual Report for 1936 contained a reference to the death of Mr. E. P. West, late Secretary-Manager of the Station for a long period of years, which took place at the end of April, 1937, as the report in question was about to go to press. The brief notice of his work for the Station which was then given indicated the very heavy loss which the Department has sustained. In consequence of his death considerable changes have been necessitated in the administrative and other arrangements. As regards office staff, Mr. A. L. Leggett, the Accountant of this Department, has been appointed Finance Secretary also and will in future occupy the Secretary's house at the Station. The secretarial duties associated with the National Fruit and Cider Institute have been allocated to Dr. T. Wallace and Mr. Leggett jointly, as Secretary and Assistant Secretary respectively. Mr. A. W. Ling, Agricultural Officer in charge of the Advisory Centre at Berkeley Square, will add to his duties there the charge of the farming operations carried on at the Research Station on the section of Fenswood Farm not appropriated for the fruit plantations.

Of the other changes, Mr. E. W. Fajans, Ph.D., who was appointed in January, 1936, to assist Dr. Martin with special investigations on fungicides and insecticides, which were being conducted in conjunction with Imperial Chemical Industries Limited, completed the programme of work for which he was appointed, and the post lapsed on his departure at the end of August, 1937.

Two other temporary members of the assistant staff, Messrs. C. H. Hardy, B.Sc., and R. G. Munson, B.Sc., who were engaged on aspects of the pathological investigations with which the Imperial Chemical Industries Limited were also concerned, gave up their respective appointments during the course of the year. In the case of the latter Mr. E. H. Wilkinson, B.Sc., is continuing his section of the work, and for a few months after Mr. Hardy's departure Miss M. Carleton, Ph.D., was engaged temporarily to bring his part of the investigation to a conclusion.

Another resignation to take effect during the year was that of Mr. J. E. Kench, M.Sc., research assistant in the chemical section, who had been associated primarily with the research on the nutrition of fruit trees. His work was continued by Mr. V. G. Vaidya, Ph.D., in the capacity of student-assistant: until that time the latter was a temporary post-graduate worker at the Station.

Reference has been made in recent Annual Reports to the rapid increase in the Station's work in the Fruit Products Section. To meet the heavy demands resulting therefrom temporary arrangements had been in force since the summer of 1935 as regards assistant staff. The position has been greatly improved during 1937 by the sanction given by the Ministry of Agriculture and Fisheries to the establishment of a post of a more permanent order. This has been filled by the appointment of Mr. V. E. Sills, B.Sc., of Birmingham University, who took up his duties in June in time for the beginning of the season's work on the soft fruit crop.

Buildings and Land.

The principal addition to the permanent buildings of the Station has been the Director's house, the decision to provide this as the first instalment of a housing scheme for certain key members of the staff having been reported in the 1936 Annual Report. The house in question has now been completed and has been in occupation since the end of September, 1937. To reach the site selected for the housing scheme a concrete road has been made through the fruit plantations on the north side of the main road.

The other building changes to be noted during the year are in the nature of alterations rather than additions. The accommodation under glass in the pot culture enclosure has been increased by the re-erection of a lean-to greenhouse formerly situated near the laboratory building. In the latter the lean-to greenhouse on the south side of the building has been converted into an appropriate structure for certain types of chemical work such as the determination of nitrogen by the Kjeldahl method, which it was desirable to remove from the rooms inside the building.

In the cider block of buildings temporary alterations have been carried out on the topmost floor of the main building to provide suitable accommodation necessary for some of the more recent work on the production of unfermented apple juice beverages.

No additional land for the extension of the fruit plantations has been enclosed off from the part of the farm not yet under fruit and the total acreage included in the fruit section of the farm thus remained practically unchanged during the year. The additional space for future fruit experiments obtained towards the end of 1936 and recorded in the Report for that year is being prepared for future planting with fruit and for the next few years may be mainly occupied with nursery material. The only other previously unplanted area of land within the fruit enclosure was the western end of the large cider orchard in course of establishment on the northern slope of the hillside on the south side of the railway. This orchard has been formed by a series of plantings in successive years and has now been completed by the addition of the remaining trees required during the last planting season.

Although in other parts of the fruit plantation there have been changes due to the removal of plots which have served their purpose and material on these plots has been replaced, there is little to record as regards the establishment of any new experimental plots of a major order.

Establishment of Plantations Technical Sub-Committee.

In view of the considerable extension in acreage of the experimental fruit plantations at the Station during the course of the past few years and the segregation of the greater part of the experimental spraying in a newly established section of the plantations, a special Plantations Technical Sub-Committee has been appointed. This Committee has been allocated the responsibility of co-ordinating the work on both the pomological and pathological sides and of preparing detailed schemes when fresh experimental plots are to be established. The Committee consists of Dr. T. Wallace, Deputy Director of the Station, Dr. H. G. H. Kearns (representing the Plant Pathology staff), and Dr. T. Swarbrick (representing the pomological staff).

General.

Annual Field Day. The Annual Field Day of the Station was held on Thursday, May 6th. Included in the programme, in addition to the sampling of ciders made in connection with the cider competitions and the experiments in the cider house for the year, were exhibits showing various forms of fruit products, including fruit-flavoured milk shakes, illustrating recent researches at the Station on this subject. An additional feature on this occasion was an exhibit illustrating the commercial manufacture of various fruit products and investigations on some of the problems connected therewith. Demonstrations were given by members of staff in the plantations on the establishment and after-care of cider orchards with special reference to (*a*) types of trees for planting, (*b*) staking and fencing methods, (*c*) shaping and pruning of the head of the tree, (*d*) methods of head-working unprofitable trees, (*e*) methods of disease and pest control ; the latest developments in materials and methods for control of diseases and pests of fruit and market garden crops ; and on the effects of deficiencies of various manurial constituents on apples, gooseberries, blackcurrants, raspberries and strawberries. The thanks of the Station are again due to the Ministry of Agriculture and Fisheries for the additional interest lent to the occasion by the exhibit relating to the Ministry's National Mark Schemes, which was staged in the cider house.

The British Broadcasting Corporation arranged for a broadcast of part of the day's proceedings in its West Regional Programme, the broadcast of the previous year's function having aroused much interest.

The weather was again very favourable and there was a very large attendance of cider makers, fruit growers, market gardeners and others interested in the Station's activities. The prizes were distributed to the successful competitors in the Institute's Cider Competitions by The Rt. Hon. The Earl of Feversham, Parliamentary Secretary of the Ministry of Agriculture and Fisheries, who also gave an interesting address.

Station Broadcast. On July 5th, at the invitation of the British Broadcasting Corporation, a description of various aspects of the work of the Station was broadcast through the West Regional Station. Members of the staff taking part in the broadcast were Dr. T. Wallace, Deputy Director, Mr. V. L. S. Charley, Dr. H. G. H. Kearns, Dr. T. Swarbrick, with Mr. A. W. Ling, the Agricultural Advisory Officer of the Department, acting as compere.

Fruit Products. The work in the fruit products section of the Station has been developed in various directions during the course of the year. The close association of the members of this section of the staff with the work of the factory of Messrs. H. W. Carter & Company, of Bristol, established the previous year for the manufacture of fruit syrups according to Long Ashton methods outlined in the Annual Report for 1936, has been continued on somewhat similar lines. The value of this working arrangement has been demonstrated in many ways since it was originally entered upon.

A somewhat different form of co-operation has been established during the year with the Metal Box Company. This firm, in view of its interest in the possibilities of canning various fruit products, such as the fruit syrups referred to above and, more particularly, unfermented apple juice and other fruit beverages, has been conducting experiments jointly with the Long Ashton staff at the Station during the course of the year and has assisted also by placing the services of some of the members of its technical staff at the disposal of the Station temporarily. With this help it has been possible to make considerable headway in the direction of the production of an unfermented apple juice beverage of a similar type to the product now being widely consumed in Germany and other parts of the Continent. Very promising results have been obtained and much useful information has been secured in connection with various problems associated with the suitability of the beverage as a commercial product and the production of a form suitable for use in can or bottle.

Show Exhibits. The Station has again been called upon heavily for exhibits for agricultural and other shows. A novel feature was introduced at the Bath and West Show by the presentation of working laboratories in the Agricultural Education and Research Pavilion by means of which it was hoped to give visitors some insight into the way in which scientific problems are tackled by the research worker. This exhibit aroused considerable and widespread interest and requests, which have had to be refused on the score of expense, have since been received for its repetition at other shows. The complete list of shows and exhibitions to which exhibits were sent during the year is as follows :—

Devon County Show, Paignton.
Asparagus Show, Evesham.
Bath and West Show, Trowbridge.
Royal Horticultural Society's Show, Chelsea.
Three Counties Show, Hereford.
Cheltenham Spa Floral Fete, Cheltenham.
Royal Agricultural Show, Wolverhampton.

Royal Welsh Agricultural Society's Show, Wolverhampton.
Gillingham and Shaftesbury Show, Shaftesbury.
Melplash and District Show, Bridport.
Imperial Fruit Show, Birmingham.

Visitors and Visiting Parties. In addition to the list of organized parties given below, many individual visitors have been received by the Station, including a large number from overseas.

Colston's Girls' School.
Somerset Teachers' Refresher Course.
"Western Daily Press and Mirror" Social Club.
Reading University Students.
Studley Horticultural College.
Great Western Railway (Bristol) Institute and Welfare Association.
Workers' Educational Association.
Geographical Society (Bristol Branch).
Fishponds Diocesan Training College.
Bishop Road Evening Institute Gardening Class.
Merchant Venturers' Technical College Pharmacy Students' Association.
Crypt School, Gloucester.
Electrical Association for Women (Bath Unit).
Sexey's School, Bruton, Somerset.
Dutch Fruit Growers. (Two parties.)
Domestic Fruit and Vegetable Preservation Courses, Cirencester.
National Co-operative Men's Guild.
St. George Secondary School Biological Class.
Trowbridge County High School for Girls.
Somerset Bee-keepers' Association.
Bristol University Summer School.
Bath Society of Pharmacy Students.
Bristol Unionist Association (West Division, Women's Branch).
Bristol University Botanical Society.

Research Students and Voluntary Workers. During the course of the year the following post-graduate workers have been engaged in research at the Station :—Mr. D. L. G. Davies, B.Sc., Mr. V. G. Vaidya, B.Ag., Mr. H. H. Khan, B.Sc., Mr. Y. V. Rao, B.Sc., and Mr. E. H. Wilkinson, B.Sc. In addition Miss M. Bakker, from the Laboratorium voor Tuinbouwplantenteelt, Wageningen, Holland, studied as a voluntary worker for six weeks during the course of the summer.

Acknowledgments. To the many individuals and institutions collaborating in the work of the Department or otherwise assisting it during the year cordial thanks are tendered for the valued help.

Also to all grades of workers on the staff a special word of appreciation of their support under the difficult conditions of the year is due.

PEAR BREEDING INVESTIGATIONS.

By G. T. SPINKS.

A small programme of pear breeding was commenced at Long Ashton in 1920 with the primary object of producing improved varieties. Although there was no intention of carrying out a thorough investigation of the genetics of pears, records of fruit and tree characters of all seedlings were kept in the hope that this information would be of value when further breeding of pears was attempted. The present article deals with the first few families raised, and gives an account of the practical results obtained and the observations made on the seedlings of these families.

GENERAL ACCOUNT OF THE INVESTIGATIONS.

The main objective in raising seedlings was the production of new sorts which would combine high fruit quality with heavy and regular cropping and, if possible, with resistance to disease. The variety Conference satisfies the last two conditions and families of seedlings were therefore raised by crossing this variety with others of higher fruit quality. In every case Conference was used as the male parent, while the female parents consisted of Doyenné du Comice, Durondeau, Dr. Jules Guyot, Louise Bonne of Jersey and Williams' Bon Chrétien. (In the following parts of this article, and in the tables, commonly used contractions of these names are employed in place of the full names).

Cross-pollination was carried out in paper bags on trees in the open, different families being raised in the years from 1920 to 1925. All seedlings have been grown on their own roots as "regulated" bush trees and propagated on quince stocks only if they showed promise of practical value. Records of various fruit and tree characters, which are tabulated and discussed below, were collected until the seedling had borne two or three crops, after which the tree was destroyed unless it appeared to be worth propagating. A very small number of trees bore fruit when only six years old, but the majority of the seedlings started to crop at the age of seven or eight years.

The families contained 39, 9, 10, 35 and 59 seedlings respectively. In a few cases trees have died or been destroyed before they fruited, but, with these exceptions, records of fruit and tree characters have been obtained from four complete families. In the last family raised (Comice × Conference) 19 trees have not yet fruited and, though the whole family is included in the records of tree characters, only 20 seedlings are dealt with under the heading of fruit characters.

The available data have been analysed and are presented in the form of tables, in which the characters of the parents are also indicated. Each character is considered separately in the succeeding sections.

ANALYSIS OF RESULTS.

Fruit Characters.

Fruit Shape (Table I).

The shape of fruits has been indicated here in two ways. Firstly, fruits have been classified by inspection under the shapes described as calebash, pyriform, conical, oval and bergamotte. Naturally some fruits could be described as intermediate in shape, and on this account it is inadvisable to lay emphasis on the relative numbers of those described as pyriform and conical. The great majority in each family fall into these two classes, and after allowing for intermediate forms it appears that the two shapes are about equally common in each family. Definitely oval fruits were found in only two cases, while the bergamotte shape occurred six times and the calebash four times. As there is no wide range of shape in the parents, which are all pyriform or conical, though Comice and Williams are somewhat oval, the occurrence of the bergamotte shape in three families is of interest. The appearance of the few calebash fruits might perhaps be expected, as the fruits of Conference sometimes approach this shape. In some cases trees bearing conical or pyriform fruits also bore some of distinctly calebash shape, but the latter were always found to be seedless and had evidently not been properly fertilized.

The shape of fruits has also been indicated by a figure which shows the ratio of the length to the breadth expressed as a percentage of the latter. The table shows that the mean figure for the parents is 150 in the case of the crosses involving Conference, Durondeau, Guyot and Williams and that the seedlings of each of these families show the same mean figure. In each of these cases there is a considerable range in shape in the seedlings, but shapes near the mean are more common than those at the extremes of the range. The extremes of shape found are indicated by the figures 100 and 200. In the family Comice × Conference the mean shape of the parents is rather shorter than that in the three preceding families, and the mean shape of the seedling fruits is also shorter. On the other hand the mean figure for Louise Bonne and Conference is slightly higher and this is also the case in the seedlings from this cross.

All the figures in this table suggest that there is a graded inheritance of shape in the families considered, and that the mean figure for each family is equal to the mean for the parents. Seedlings of each family apparently show a much wider range of shape than their parents, but it should be noted that only the mean value for each parent, and not the range covered by the fruits of that parent, is indicated in the table.

Fruit Size (Table II).

The size of fruits has been judged from the measurement of their length. The figures in the table show that in each family there is a considerable range of fruit size, the fruits of medium size being the most numerous in each case. The mean size of the seedling fruits in each family appears to be considerably less than the mean for the two parents, but it should be noted that the size of the seedling fruits was probably reduced by the conditions of growth and culture, also that the sizes given for the parents probably represent the largest grade in each variety, rather than an average sample.

The table, however, shows that the size of seedling fruits is correlated to some extent with that of the parents, for the lowest mean value for seedlings occurs in the family whose parents, Comice and Conference, show the lowest mean for parents. Williams × Conference shows a high mean figure for both parents and seedlings, while Louise Bonne × Conference is intermediate in both cases. The number of observations for the other two families are probably too small to be of much significance.

Skin Characters of Fruit (Table III).

The ground colour of the skin was noted when fruits had reached the state of ripeness when they were ready for use. Skins were described as green, golden or pale yellow, though possibly intermediate colours also occurred. The table shows that in the families

Guyot × Conference and Louise Bonne × Conference, in which the skin of both parents was pale yellow, the majority of seedling fruits were pale in colour, though golden fruits were also found. Four seedlings out of 28 derived from Louise Bonne × Conference were described as green when ripe, but a yellow colour developed in over-ripe fruit. Where one parent bore golden fruit the numbers of golden and pale yellow fruits amongst the seedlings were either approximately equal, as in the families Durondeau × Conference and Williams × Conference, or golden skins were in excess of pale ones, as in the seedlings of Comice × Conference.

The fruits of two parents, Durondeau and Louise Bonne, bear distinct red flushes, and seedling fruits derived from these varieties include a larger proportion of distinctly flushed fruits than are found in families whose parents bear only an occassional slight flush. In each family one parent, Conference, shows no flush.

The amount of russet on the seedling fruits was found to be greatest in the family Comice × Conference in which both parents are much russetted, 15 seedlings out of 20 bearing much russet and only one being free from it. The cross between Williams (slight russet) and Conference produced a large proportion of fruits with slight russet, 28 out of 58, but only three seedlings without russet. Where one parent, Louise Bonne, bore entirely smooth fruit the cross with Conference resulted in a larger proportion of seedling fruits without russet and a smaller proportion with much, the numbers being 5, 16 and 7 for no russet, slight and much russet. In the other families the small number of seedlings renders the figures of little significance.

Flesh Characters of Fruit (Table IV).

The colour, texture and juiciness of the parents and of seedling fruits are given in Table IV. Colour was described as yellow, cream or white, but in some cases there was some doubt as to the category in which the fruit should be placed. Where the colour of the parent occupies an intermediate class it has been placed in two classes, *e.g.* the flesh of Comice being a deep cream, that variety has been put in both the cream and yellow classes. Cream flesh is most abundant in every family, while only two seedlings were described as white-fleshed. Among the seedlings from Williams × Conference 17 out of 58 were placed in the yellow group, but it is probable that many of these would be more properly described as deep cream: in the other families a much smaller proportion of yellow-fleshed fruits was noted.

The texture of flesh was described as tough, firm or soft, and in some cases as gritty. All the parents except Durondeau have soft flesh which is sometimes described as tender or melting. The flesh of Durondeau, described as firm, has a texture intermediate between soft and crisp. Among the seedlings soft flesh occurred most frequently, except in the fruit derived from Comice and Durondeau where firm flesh was slightly more common. In the other families firm flesh was noted in about 30% of the seedlings. Fruits with tough flesh were found in small numbers only. Some fruits included in the above three classes contained a layer of more or less gritty flesh surrounding the core : these numbered almost 50% of the seedlings in each family, except that derived from Durondeau and Conference. In the table the question marks indicate that the fruits were only slightly gritty. It is notable that none of the parents are described as gritty.

The amount of juice in fruits ranged between good and poor, all the parents being classed as good. Seedlings from Guyot × Conference included 7 out of 10 with good juice, in three other families nearly 50% of the seedlings were placed in this class, but the proportion was lower in the family Williams × Conference. Flesh with poor juice was comparatively rare in every family.

Flavour of Fruit (Table V).

Sweetness, acidity, aroma and astringency of fruits were noted when considering their flavour.

In the two largest families fruits with good and medium sugar were approximately equal in numbers, while in the other three families the proportion with good sugar was higher, sweetness of the fruits derived from Comice being notable. In no case was the amount of sugar described as poor. As in every parent, with the possible exception of Guyot, sugar content was good, the average sweetness of the seedling fruits in each family was slightly lower than that of the parents.

Three seedlings only produced fruit of high acidity, one occurring in each of the families derived from Comice, Louise Bonne and Williams. Fruits with medium acid were rather more numerous than those with poor acid among the seedlings from Comice and Conference, but in all the other families fruits with poor acid were in a majority, the higher proportion of low-acid fruits being especially marked in the family Williams × Conference. Though Durondeau was classed as medium acid, the acidity of all the other parents was described as low, and it is evident that the average acidity of seedlings was rather higher than that of the parents.

Fruits with a really first-class aroma, described as good, were comparatively few, though 6 out of 18 seedlings derived from Comice were placed in this class. The proportion was smaller in each of the other families, and none of the seedlings derived from Louise Bonne reached this standard. The class with a fairly good aroma contained the largest number of seedlings in each family, while a medium aroma was less common, except in the family Louise Bonne × Conference. A definitely poor aroma was found in only two cases. The aroma of Conference and Guyot was described as fair, while that of the other three parent varieties was classed as good. It is therefore evident that the average aroma of seedling fruits was poorer than that of the parents in four out of the five families, but the combination of the varieties Guyot and Conference produced two seedlings with a better aroma than that of either of the parents. Good aroma appears to have been successfully transmitted by Comice but not by Louise Bonne. In one seedling from Comice, and in six from Williams the aroma was noted as being very strong, though not necessarily pleasant.

About 10% of the seedlings in each family bore fruit of a distinctly astringent character, which is not found in any of the parents.

Season and Use of Fruit (Table VI).

In every family of seedlings there was a considerable range in the season of the fruits and in every case, except that of Guyot × Conference, seedlings both earlier and later than either of the parents were found, though the average for the seedlings in each family was roughly the same as the average of the parents.

The number of seedlings classed as December onwards is notable but possibly misleading. Many of these, even if picked very late, never ripen properly but remain hard until they begin to shrivel without rotting: possibly such fruits may be suitable for culinary use earlier in the season. Fruits of this type were found in each family, except that derived from Guyot.

The great majority of the seedling fruits were classed as dessert varieties, though some are of only moderate quality. The numbers of the latter type are indicated by the figures followed by question marks in the " dessert " column. Only three seedlings were classed as cooking varieties, but, as mentioned above, some of the small number shown in the " useless " column should possibly be included among the cooking sorts.

Tree Characters.

Tree Size and Habit (Table VII).

In every family trees of large and medium size (considering their age) were about equally numerous, while small trees occurred much less frequently. All the parents, with the exception of Durondeau, were classed as medium in size.

A medium habit of tree was usually the most common, though erect trees were almost as numerous, while spreading trees were comparatively rare. It must be remembered, however, that the notes were made on young trees, and that in some cases the habit would probably become less erect with increasing age. As far as can be judged from a small family, the erect parent Guyot has produced a larger proportion of erect seedlings, 7 out of 10, than any of the other parents, which are all medium in habit.

Time of Blossoming.

Times of blossoming were observed on all seedlings, but no figures are presented in the tables. The range in the blossoming times of the parents is not large and the seedlings show no great differences. It can be stated, however, that seedlings from the early variety Louise Bonne were slightly earlier than the average, while those from the late variety Comice were slightly later.

Susceptibility to Diseases.

Scab and Canker (Table VII).

In the family derived from Comice, nearly half the seedlings have shown a medium attack of scab, while four plants have been badly attacked. The figures for this family, however, are liable to revision, as some of the trees are still young and have been classified on only a few observations, including some bad scab years: after a more extended observation some of the seedlings may appear less susceptible. In the small family Durondeau × Conference medium attacks of scab were the most common. In the other three families, including those derived from the susceptible varieties Louise Bonne and Williams, the great majority of seedlings have been either free from scab or only slightly attacked. A small number of seedlings in each of these families have shown a medium attack; while the disease has been bad on a still smaller number. The resistant variety Conference appears to have transmitted a considerable degree of resistance in every family.

Seedlings derived from Comice have shown the highest proportion of attacks of canker, the disease being bad on 4 and medium on 5, out of a total of 38 trees. In all the other families bad or medium attacks have occurred on very few trees, even the seedlings from the susceptible variety Louise Bonne including only one tree with more than a slight attack. Possibly the resistance of Conference to the disease has been a factor in producing this result.

Selections.

The last column of Table VI indicates the number of seedlings selected for propagation and further trial, and it will be noticed that each family has yielded something of possible value. The cross Louise Bonne × Conference contains the smallest number of promising seedlings in proportion to the size of the family. Several of the selected seedlings have already been discarded on account of various faults, the most common of which is the habit of the fruit of ripening from the core while the skin is still green, a serious disadvantage from a commercial point of view. Other selections are still proving satisfactory and one seedling variety, derived from Williams × Conference, has already been distributed under the name of Bristol Cross.

DISCUSSION.

The data concerning the various characters were in almost every case obtained by observation and were not measurable by definite standards. The figures shown in the tables are therefore subject to errors of judgment and cannot be considered to exhibit a high degree of accuracy. Moreover, the parents themselves did not show any marked differences in respect of a number of characters.

Bearing these facts in mind, an examination of the various tables does not suggest that any definite segregation of characters has been found in the families of seedlings. Variation appears to have been continuous as regards shape, size, skin characters, flesh and flavour of fruit, season of blossoming and fruit ripening, and habit of tree. There seems, however, to have been a certain amount of dominance of resistance to scab and canker.

In the case of most characters, there has apparently been a graded inheritance from both parents and the mean for the seedlings has approximated to that of the parents, but the range of variation has been wider in the case of the seedlings. This is seen in the occurrence of a few fruits of bergamotte shape, tough and gritty flesh, high acidity and poor aroma, none of which characters appear in any of the parents. In most families the seedlings have included varieties earlier and later in season than either of the parents.

From the breeder's point of view the crosses have shown a fair degree of success, for, though a number of inferior fruits have been obtained, 16 seedlings out of 114 have been thought worthy of propagation for further trial. In most of these the desired combination of good fruit quality, productiveness and resistance to disease seems to have been obtained, and, though a few are now showing other undesirable characteristics, several are continuing to give satisfaction.

SUMMARY.

Seedling pears have been raised from crosses between Conference and Doyenné du Comice, Durondeau, Dr. Jules Guyot, Louise Bonne of Jersey, and Williams' Bon Chrétien respectively. The number of seedlings in each family ranged between 50 and 9.

Various fruit characters, tree characters, season of blossom and fruit, and susceptibility to disease have been observed on all seedlings.

No sharply discontinuous segregation of any character has been found in any family.

In each family a continuous variation has been found, the range usually extending beyond that of the parents.

Seedlings which appear to combine high fruit quality, productiveness and resistance to disease have been selected from each family, the total number of selections being 16. Selected seedlings have been propagated and are undergoing further trial.

TABLE I.

SHAPE OF FRUIT.

Parents.	*Number of Seedlings.*										
	Shape Category.					$\frac{\textit{Length} \times 100}{\textit{Breadth}}$					
	Calebash.	*Pyriform.*	*Conical.*	*Oval.*	*Bergamotte.*	200	180	160	140	120	100
Comice × Conference	–	6	12	–	2	–	–	6	6	7	1
Comice	–	*	–	*	–	–	–	–	–	*	–
Conference	–	*	–	–	–	–	–	*	–	–	–
Durondeau × Conference	–	3	5	–	–	–	1	3	3	1	–
Durondeau	–	–	*	–	–	–	–	–	*	–	–
Conference	–	*	–	–	–	–	–	*	–	–	–
Guyot × Conference	–	3	6	–	1	–	2	3	2	2	1
Guyot	–	*	–	–	–	–	–	–	*	–	–
Conference	–	*	–	–	–	–	–	*	–	–	–
Louise Bonne × Conference	2	11	13	2	–	2	9	8	7	2	–
Louise Bonne	–	–	*	–	–	–	–	*	–	–	–
Conference	–	*	–	–	–	–	–	*	–	–	–
Williams × Conference	2	31	22	–	3	4	7	22	17	6	2
Williams	–	*	–	*	–	–	–	–	*	–	–
Conference	–	*	–	–	–	–	–	*	–	–	–

* Indicates data for parents.

TABLE II.

SIZE OF FRUIT (LENGTH IN INCHES).

Parents.	*Number of Seedlings.*					
	2.0 *ins.*	2.5 *ins.*	3.0 *ins.*	3.5 *ins.*	4.0 *ins.*	4.5 *ins.*
Comice × Conference	2	9	7	2	–	
Comice	–	–		*	–	
Conference	–	–	–	–	–	*
Durondeau × Conference ..	–	–	5	3	–	–
Durondeau	–	–	–	–	*	–
Conference	–	–	–		–	*
Guyot × Conference	–	1	5	2	2	–
Guyot	–			–	–	*
Conference		–			–	*
Louise Bonne × Conference ..	2	5	12	6	3	–
Louise Bonne	–	–	–	–	*	–
Conference	–	–		–	–	*
Williams × Conference	4	9	19	17	8	1
Williams	–	–	–	–	–	*
Conference	–	–		–	–	*

* Indicates size of parents.

TABLE III.

SKIN CHARACTERS OF FRUIT.

Parents.	*Number of Seedlings.*						
	Green.	*Gold.*	*Pale Yellow.*	*Flushed.*	*No Russet.*	*Slight Russet.*	*Much Russet.*
Comice × Conference	–	13	7	3 ?	1	4	15
Comice	–	*	–	* ?	–	–	*
Conference	–	–	*	–	–	–	*
Durondeau × Conference ..	–	4	4	1+4 ?	0	4	4
Durondeau	–	*	–	*	–	*	–
Conference	–	–	*	–	–	–	*
Guyot × Conference	–	3	7	4 ?	2	6	2
Guyot	–	–	*	* ?	–	*	–
Conference	–	–	*	–	–	–	–
Louise Bonne × Conference ..	4	7	17	4+7 ?	5	16	7
Louise Bonne	–	–	*	*	*	–	–
Conference	–	–	*	–	–	–	*
Williams × Conference	–	27	31	3+4 ?	3	28	27
Williams	–	*	–	* ?	–	*	–
Conference	–	–	*	–	–	–	*

* Indicates characters of parents.

TABLE IV.

Flesh Characters of Fruit.

Parents.	*Number of Seedlings.*										
	Colour.			*Texture.*				*Juice*			
	Yellow.	*Cream.*	*White.*	*Tough.*	*Firm.*	*Soft.*	*Gritty.*	*Good.*	*Fairly Good.*	*Medium.*	*Poor.*
Comice × Conference	3	15	–	1	9	8	9	8	5	3	2
Comice	*	*	–	–	–	*	–	*	–	–	–
Conference	–	*	*	–	–	*	–	*	–	–	–
Durondeau × Conference ..	2	5	1	1	4	3	–	3	–	5	–
Durondeau	–	*	–	–	*	–	–	*	–	–	–
Conference	–	*	*	–	–	*	–	*	–	–	–
Guyot × Conference	2	8	–	–	4	6	1+4 ?	7	1	2	–
Guyot	–	*	–	–	–	*	–	*	–	–	–
Conference	–	*	*	–	–	*	–	*	–	–	–
Louise Bonne × Conference ..	1	25	1	2	8	17	3+8 ?	12	4	10	1
Louise Bonne	–	–	*	–	–	*	–	*	–	–	–
Conference	–	*	*	–	–	*	–	*	–	–	–
Williams × Conference	17	41	–	2	16	40	14+13 ?	18	10	25	5
Williams	–	*	–	–	–	*	–	*	–	–	–
Conference	–	*	*	–	–	*	–	*	–	–	–

* Indicates characters of parents.

TABLE V.

FLAVOUR OF FRUIT.

Parents.	Number of Seedlings.									
	Sugar.			Acid.			Aroma.			
	Good.	Medium.	Poor.	Good.	Medium.	Poor.	Good.	Fairly Good.	Medium.	Poor.
Comice × Conference	15	3	–	1	10	7	6	7	4	1
Comice	*	–	–	–	–	*	*	–	–	–
Conference	*	–	–	–	–	*	–	*	–	–
Durondeau × Conference	6	2	–	–	3	5	2	4	2	–
Durondeau	*	–	–	–	*	–	*	–	–	–
Conference	*	–	–	–	–	*	–	*	–	–
Guyot × Conference	7	3	–	–	4	6	2	6	2	–
Guyot	* ?	*	–	–	–	*	–	*	–	–
Conference	*	–	–	–	–	*	–	*	–	–
Louise Bonne × Conference	13	14	–	1	10	16	–	13	13	1
Louise Bonne	*	–	–	–	–	*	*	–	–	–
Conference	*	–	–	–	–	*	–	*	–	–
Williams × Conference	31	27	–	1	16	41	2	35	21	–
Williams	*	–	–	–	–	*	*	–	–	–
Conference	*	–	–	–	–	*	–	*	–	–

* Indicates characters of parents.

TABLE VI.

SEASON AND USE OF FRUIT. SELECTIONS FOR TRIAL.

Parents.	*Number of Seedlings.*										
	Season.							*Use.*			*Selected.*
	Aug.	*Early Sept.*	*Late Sept.*	*Early Oct.*	*Late Oct.*	*Nov.*	*Dec. onwards.*	*Dessert.*	*Cooking.*	*Useless.*	
Comice × Conference			1	3	7	4	5	10+6 ?		4	3
Comice		–				*	–	*		–	
Conference	–	–	–		*	*	–	*	–	–	–
Durondeau × Conference . .		–	1	2	2	1	2	5+2 ?		1	1
Durondeau	–	–	–	*	*	–	–	*		–	–
Conference	–	–	–	–	*	*	–	*	–	–	–
Guyot × Conference	–	2	3	3	2	–	–	8+1 ?	–	1	2
Guyot	–		*	–	–	–	–	*	–	–	–
Conference	–	–	–	–	*	*	–	*	–	–	–
Louise Bonne × Conference . .	–	1	7	5	5	4	6	12+10?	1 ?	5	2
Louise Bonne	–	–	–	–	*	–	–	*	–	–	–
Conference	–	–	–	–	*	*	–	*	–	–	–
Williams × Conference	2	2	12	14	14	4	10	37+15 ?	2 ?	4	8
Williams	–	*	–	–	–	–	–	*	–	–	–
Conference	–	–	–	–	*	*	–	*	–	–	–

* Indicates season and use of parents.

TABLE VII.

Tree Size and Habit. Susceptibility to Scab and Canker.

Parents	*Number of Seedlings.*											
	Size.			*Habit.*			*Scab.*			*Canker.*		
	Large.	*Medium.*	*Small.*	*Erect.*	*Medium.*	*Spreading.*	*Slight or none.*	*Medium.*	*Bad.*	*Slight or none.*	*Medium.*	*Bad.*
Comice × Conference	16	14	5	12	22	1	19	5 + 10 ?	1 + 3 ?	29	5	4
Comice	–	*	–		*	–		*	–	*	–	–
Conference		*	–		*		*		–	*		–
Durondeau × Conference . .	3	5	1	2	6	1	3	5	1	9	–	
Durondeau	*	–	–	–	*	–	–	*		–	*	–
Conference		*		–	*		*			*	–	
Guyot × Conference	6	4		7	3	–	8	2	–	9	1	–
Guyot		*	–	*	–	–		*	–	*	–	–
Conference	–	*	–		*	–	*		–	*	–	–
Louise Bonne × Conference . .	18	15	2	17	15	3	30	3	2	34	–	1
Louise Bonne	–	*	–	–	*		–		*	–	–	*
Conference	–	*	–	–	*		*			*		–
Williams × Conference	30	25	4	20	34	5	44	9	6	56	2	2
Williams	–	*	–	–	*				*	*		–
Conference	–	*	–	–	*		*			*		–

* Indicates characters of parents.

A COMPARISON OF PRUNING TREATMENTS IN RELATION TO APPLE-TREE SHAPE.

PROGRESS REPORT.

By T. SWARBRICK and W. E. BERRY.

INTRODUCTION.

The behaviour of apple trees of different varieties worked on to a common rootstock and given no cultural treatment whatsoever after planting would be determined entirely by varietal characteristics subject to the influence of the particular conditions of soil and climate. This seldom occurs in practice, growth and cropping being drastically modified by cultural operations, particularly manuring, pruning and soil cultivation. Of these, there is no doubt that pruning can bring about the most drastic alterations, since by its use or misuse, a tree may be made large or small, fruitful or unfruitful, symmetrical or shapeless. Growth may be stimulated in chosen regions of the tree and suppressed in others. Summer pruning may be used to induce growth at a time when this would otherwise cease, to improve the appearance of fruit by allowing access of light, or to encourage the formation of fruit buds by a redistribution of growth centres and redirection of available carbohydrates. On the other hand, too drastic summer pruning may so reduce the photosynthetic area of the tree as to impair the crop and the following season's growth through lack of carbohydrate. It is possible by adopting suitable pruning methods to adapt the shape and growth habit of a tree in accordance with specified objects, to produce, for instance, a tree with strong crotches and a crop consisting of a controlled number of well formed fruits of suitable size.

Swarbrick (9) has recently described methods of pruning used in developing two types of tree suitable for commercial use. These are the " open centre " type, a variation of the classical vase-shaped tree of the fruit garden, and the " modified leader," in which the central leader is developed to any desired height and approximately horizontal branches encouraged at suitable positions along its length. Typical trees of both shapes are shown in figs.

1 and 2. The present report, which covers the first eleven years of a pruning experiment, is concerned with a comparison of the behaviour of five varieties of apple receiving five different pruning treatments including the training of open centre and modified leader trees.

EXPERIMENTAL.

Material and Treatments.

The varieties used are Worcester Pearmain, Cox's Orange Pippin, Allington Pippin, Edward VII and Emneth Early (Early Victoria). All the five treatments included winter pruning, but this was carried out in such a way as to produce three different shapes of tree, namely " open centre," " modified leader " and " regulated," the latter involving minimum cutting, pruning being confined to a removal of crossing branches and thinning out where necessary. In addition to winter pruning, summer pruning was carried out on some of the open centre and modified leader trees. The five treatments were as follows :—

I. Regulated .. .. winter pruned.
II. Open Centre .. winter pruned.
III. Open Centre .. summer and winter pruned.
IV. Modified Leader .. winter pruned.
V. Modified Leader .. summer and winter pruned.

(Trees receiving both summer and winter pruning will be referred to in the text as " summer pruned " trees).

The trees were planted as one-year-old whips on Malling Type II in the winter of 1926. Initially eight varieties were planted, but for various reasons the varieties Newton Wonder, Blenheim Orange and Beauty of Bath were headworked to different sorts. The data collected therefore refer only to the five remaining varieties already mentioned. It should be pointed out also that the trees were at first intended for use in a simple variety trial, and were all headed back hard in winter 1927 and again in 1928 with the intention of training them as open centre trees. The differential pruning was only begun in the third year after planting, so that, in effect, the training of the open centre trees was begun two years in advance of the modified leader and regulated types. The plot was arranged in twelve blocks, each block being divided into five treatment plots, each of which contained one tree of each variety. The varieties and treatments were not fully randomised but were distributed systematically over the plot. In view of the relative uniformity of the soil over the area and the high degree of replication (60 trees of each variety or 12 of each variety for each treatment) the statistical validity of the data is not thereby appreciably diminished. The planting distance was 15ft. apart each way, and at the present time some trees are almost touching in both directions. The distance could with advantage have been increased to 18ft.

Pruning and Other Cultural Treatments.

Cultivation and Manuring. The plot on which these trees are growing was ploughed out of grass land in the winter of 1924. Two successive grain crops were taken in the years prior to planting. An interplant of black currants was set at the same time as the trees and this remained until the winter of 1930 when the interplant was removed. Since that date clean cultivation has been maintained by means of tractor and horse cultivation.

Artificial manures have been used throughout, nitrate of soda, superphoshphate and sulphate of potash. The rates in cwts. per acre given in the above sequence. were as follows :—In 1926 and 1927 the dressings was 2, 4, 3 ; in 1928 and 1929, 2, 3, 2. From 1930. when the black currants were removed, the annual dressing has consisted entirely of superphosphate and sulphate of potash at an average of 1¼ cwts. superphosphate and 2 cwts. sulphate of potash per acre.

Winter Pruning.

(*a*) *Regulated Trees.* These trees received very little pruning and this always during winter. All trees under this treatment were headed back so as to form open centre trees in the winter following planting (1927). Hard cutting back of all shoots was also carried out in 1928 and 1929 in order to increase the number of main branches and to set the framework of the future tree. From 1930 to 1933 pruning was very light indeed, tipping being discontinued and only an occasional crossing branch removed. From 1934 onwards it became necessary to remove an increasing number of branches, since the heavier cropping had caused these trees to become a tangled mass of rather drooping branches.

It should be emphasised at this point that the weight of prunings removed under this treatment bears no relation to the severity of the general pruning treatment. For example, one large branch removed from a regulated tree might weigh more than the whole of the prunings removed from an open centre tree, since the latter would consist almost entirely of the ends of one-year-old shoots.

(*b*) *Open Centre Trees.* The open centre trees have been developed along strictly orthodox lines. The trees were not cut back at the time of planting, but were headed at about 2ft. 6in. during the first winter after planting. During each successive winter all leader growths have been tipped by removing from one-third to one-half their original length. Leaders have been selected and developed in an upward and outward direction, all other growths being either removed completely or else spurred by being cut back to about 5 inches long. The general aim of the pruning has been to develop a typical open centre tree, and to treat each main branch as a single cordon.

In this connection it should be pointed out that during the period 1930 to 1936 these trees developed a large number of vigorous shoots from their centres. These shoots were removed each winter and their total weight was often considerable.

(*c*) *Modified Leader Trees.* These trees were treated exactly as the open centre trees until the end of the third year after planting. In consequence, the shaping of the modified leader trees as such, only began at the end of the third winter from planting. At this time a leader was selected and developed as the main axis of the tree. From this central stem as leader, main branches were developed according to the principles laid down by one of us (T.S.) in " Scientific Horticulture."(9)

During each subsequent winter leader growths were tipped by removing one-third of their growth. Laterals were spurred to about 5 inches long. A limited amount of notching was practiced on the main leader in order to encourage branches at desirable positions.

Summer Pruning.

The summer pruning of both open centre and modified leader trees consisted of the cutting back of all current year's growths to about five leaves, except leaders which were left unpruned.

During winter the leader growths were tipped by removing one-third their length and any secondary growths arising from the summer pruned shoots were cut back to their basal buds.

The date of the summer pruning was chosen each year at such a time that the lateral bud left in the terminal position after pruning would make enough growth to form a rosette of leaves, but not enough to make much elongation growth. This date was usually about the first or second week in August.

RESULTS.

Records.

The following records were taken annually :—Weights of summer prunings ; weights of winter prunings ; lengths of summer prunings ; tree heights, spreads N.S. and E.W. ; girths at the crotch and at 1 foot from ground level ; numbers of terminal blossoms ; numbers of spur blossoms ; numbers of lateral blossoms ; numbers of fruits set ; numbers of windfalls ; numbers of "June drop" ; numbers and weights of marketable fruits. These records are not all discussed in the present report, only those being dealt with which exhibit features of interest more particularly from the practical point of view.

Winter Pruning Weights.

Apart from the pruning factor, which differs for each of the five treatments, the cultural operations on the plot were uniform so that it is well to consider in the first place the magnitude of the pruning operations in order to have in mind the extent to which this has affected the behaviour of the trees in regard to blossoming, cropping, etc. From the methods of pruning already described, it is obvious that the training of the three tree types, especially in the early years, involves the removal of wood from different regions of the tree in each case.

In the open centre trees the leader is cut hard back in the first year after planting in order to develop branches arising close together at the required height. These branches are again cut back the following year to establish the framework of the tree. Pruning is much less drastic for the modified leader trees, where the leader is headed back relatively lightly in the first year and the resulting lateral growths cut back less severely than in the case of the open centres. A complete shoot, however, may be removed where this would make a narrow angle crotch. When the trees are several years old, pruning of the open centre type involves hard cutting of laterals and comparatively little cutting of terminal shoots, whilst in the modified leader, laterals may be left longer but there are more terminal and subterminal shoots to be dealt with in order to continue the development of the correct tree shape. The pruning of the regulated tree on the other hand is confined to the removal of complete branches where it is necessary to relieve congestion in the tree head and eliminate diseased or crossing branches.

TABLE I.

MEAN ANNUAL WEIGHTS PER TREE OF WINTER PRUNINGS (KILOS).

WORCESTER.

Treatment.	1928.	1929.	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.
I	0.123	0.347	0.333	0.337	0.741	5.132	3.218	0.464	4.509	3.705
II	0.149	0.363	0.448	0.695	1.663	7.317	1.746	2.373	3.033	3.504
III	0.148	0.360	0.302	0.348	0.850	6.795	0.455	0.379	1.941	2.227
IV	0.123	0.398	0.497	0.665	2.496	7.513	1.892	2.845	3.263	3.200
V	0.107	0.333	0.401	0.485	1.827	6.309	0.418	0.787	3.532	2.237
				Cox.						
I	0.193	0.483	0.704	0.898	1.708	7.167	4.204	2.099	8.292	5.343
II	0.267	0.519	0.737	1.525	3.021	10.621	3.563	5.710	5.629	5.000
III	0.225	0.416	0.385	0.557	1.482	6.555	0.559	0.395	4.019	3.950
IV	0.160	0.475	0.768	1.399	4.142	9.417	5.057	6.103	6.892	4.758
V	0.189	0.375	0.625	0.850	2.429	6.542	0.767	0.572	3.608	2.758

In Table I are given the mean weights per tree of winter prunings for trees of Worcester and Cox subjected to the five pruning treatments. These show clearly the increased amount of wood removed as the tree develops from three to eleven years old. Although the pruning treatments are quite different it appears that in the early years there is little difference between the amounts of wood removed. A considerable difference has arisen, however, by 1932, when the modified leader trees show a relatively larger amount of wood removed. The regulated and open centre summer pruned trees have lost much less, whilst the open centre winter pruned trees occupy an intermediate position. This order is essentially the same for both Worcester and Cox.

In 1933 it was considered necessary to give a particularly heavy pruning treatment, so that the weights of wood removed have more than doubled those of the previous year. It is unfortunate that practical considerations of management should perforce enter into an experiment of this kind since there is no doubt that this heavy pruning, designed to open up the trees to facilitate spraying and cultivation has tended to even up the effects of the different treatments to some extent. In the years immediately following this hard pruning, the weights of wood removed from the various tree types fluctuate considerably and there seems little information to be gained from further examination of the data until a comparatively stable condition is reached again. It is interesting to note, however, that the wood removed from the summer pruned open centre trees remains relatively low, and the winter pruned modified leaders continue to lose considerable amounts. The regulated trees on the other hand, though receiving minimum pruning, lose relatively more weight of wood as their age increases. This is due to the removal of a few large branches. It is obvious that the weights of wood removed give little indication of the nature of the pruning treatments.

It is also of interest to compare the time spent in pruning the trees under the different treatments. From the winter of 1933, records were taken of the time required to prune each tree. No attempt was made, however, to standardise the rates of pruning, *i.e.*the trees were pruned by a number of different operators who no doubt differed considerably in their abilities. Moreover, there was no allocation of different varieties or treatments to particular pruners, so that the data obtained are subject to a number of uncontrolled variables, such as weather, speed of the pruner, etc., which cannot be estimated. The figures which are given in Tables II, III and IV can therefore be taken only as a general guide to the time required to prune trees of the various types. They are cited only for the varieties Worcester and Cox. The data for treatment I should be considered apart from the others, since it is not suggested that this type of pruning be adopted commercially. Winter pruning was carried out with pruning knives, and summer pruning with secateurs. Treatment I naturally involved the use of a saw more than anything else.

TABLE II.

WINTER PRUNING TIMES (MINUTES PER TREE).

WORCESTER.

Treatment.	I.	II.	III.	IV.	V.
1933–4	15	16	13	18	15
1934–5	13	15	5	19	9
1935–6	4	28	10	29	10
1936–7	10	12	12	16	15
1937–8	9	21	17	23	17
Mean	10	18	11	21	13

TABLE III.

Winter Pruning Times (Minutes per Tree).

Cox.

Treatment.	I.	II.	III.	IV.	V.
1933–4	20	20	13	24	16
1934–5	20	31	6	34	12
1935–6	16	53	16	53	14
1936–7	16	33	29	38	26
1937–8	13	34	24	36	30
Mean	17	34	18	37	20

TABLE IV.

Summer Pruning Times (Minutes per Tree).

	Worcester.		*Cox*	
Treatment.	III.	V.	III.	V.
1934	9	11	20	20
1935	17	16	33	34
1936	14	13	22	24
1937	16	21	26	30
Mean	14	15	20	27

The most obvious fact which arises is that trees receiving summer pruning (treatments III and V) require less expenditure of time on winter pruning than those not summer pruned, but the time spent on summer pruning raises the total time spent on these trees far beyond that spent on trees only winter pruned. Comparing open centre trees with modified leaders it appears that the latter take longer to winter prune. This applies to both the summer and winter pruned trees. The difference is two or three minutes per tree, or between 9% and 18%, which means that an acre of modified leaders would have taken from six to nine hours longer to prune than an acre of open centres. Similar differences occur when summer pruning is considered, the average time taken to prune a modified leader being rather longer than for an open centre.

Tree Size.

It is to be expected that different pruning treatments would result in differences in the dimensions of the trees. Records of the spread of the branches N.S. and E.W. were taken annually as well as the total heights of the trees and the girths at 1 foot above ground level and at the crotch. A summarised account of these data is presented in Tables V, VI and VII, showing the various growth measurements as means for 12 trees as they existed in the winter of 1937. They thus show the accumulated effects of the various treatments after 9 years differential pruning. The figures for branch spread represent the means of the two measurements N.S. and E.W. The girths are given only for the measurement at 1 foot from the ground. since the measurements at the crotch do not differ appreciably from these and supply no additional useful information.

TABLE V.

MEAN TREE HEIGHTS (METRES) 1937.

Treatment.	*Worcester.*	*Cox.*	*Allington.*	*Edward.*	*Emneth.*	*Total.*	*Mean.*
I ..	3.14	3.64	3.62	3.62	3.47	17.49	3.49
II ..	3.06	3.55	3.41	3.67	3.34	17.03	3.40
III ..	3.16	3.51	3.22	3.52	3.34	16.75	3.35
IV ..	3.37	3.83	3.64	3.74	3.52	18.10	3.62
V ..	3.25	3.73	3.49	3.71	3.43	17.61	3.52
Total ..	15.98	18.26	17.38	18.26	17.10	86.98	
Mean ..	3.20	3.65	3.68	3.65	3.42		

TABLE VI.

MEAN TREE SPREADS (METRES) 1937.

Treatment.	*Worcester.*	*Cox.*	*Allington.*	*Edward.*	*Emneth.*	*Total.*	*Mean.*
I ..	3.73	4.45	4.47	4.27	4.13	21.05	4.21
II ..	3.44	4.38	4.26	3.65	3.79	19.52	3.90
III ..	3.28	4.16	4.01	3.32	3.40	18.17	3.63
IV ..	3.35	4.21	3.85	3.71	3.59	18.71	3.74
V ..	3.12	4.11	3.90	3.67	3.51	18.31	3.66
Total ..	16.92	21.31	20.49	18.62	18.42	95.76	
Mean ..	3.38	4.26	4.09	3.72	3.68		

TABLE VII.

TREE GIRTHS AT 1FT. FROM GROUND (CMS.)

Treatment.	*Worcester.*	*Cox.*	*Allington.*	*Edward.*	*Emneth.*	*Total.*	*Mean.*
I ..	42.0	42.5	44.3	43.7	44.0	216.5	43.3
II ..	40.3	43.7	43.9	42.5	45.9	216.3	43.3
III ..	39.2	39.8	41.5	39.3	42.4	202.2	40.4
IV ..	40.0	42.9	43.3	41.0	43.2	210.4	42.1
V ..	39.5	39.8	40.7	40.8	43.0	203.8	40.8
Total ..	201.0	208.7	213.7	207.3	218.5	1049.2	
Mean ..	40.2	41.7	42.7	41.5	43.7		

S.E. = 0.40. Sig. diff. = 0.78.

The height and spread measurements show very little difference, and since it is obvious that they are more or less arbitrarily determined by the treatment applied, there seems little point at the present age of the trees in analysing these data any further, except to point out that of the five varieties, Worcester is the smallest tree as regards girth, height and spread. Of the five treatments, the regulated pruning, which involves very little cutting, results in the greatest tree size. An apparent exception to this occurs in the case of the modified leaders whose height somewhat exceeds that of the regulated trees. The trees are, however, never likely to provide very useful comparisons with respect to size, since this has already been determined by the planting distance, namely 15 feet, and reference to Table VI shows that many of the trees have a spread of 13 to 14 feet. Hard cutting back is consequently necessary particularly in the case of the modified leader trees in order to make room for cultivation and the movement of spray machinery between the rows.

The tree girth data have been analysed statistically as they form a more reliable index of the response of the tree to pruning. New growths on branches may be arbitrarily removed by pruning, leaving no indication of the amount of growth made, but the tree girth remains as a permanent record of the contributions made by root and shoot to the growth of the tree. The differences between varieties are small but significant except that between Cox and Edward. Worcester has a somewhat smaller girth than the remaining varieties, whilst Emneth has the greatest. The differences between treatments are more interesting, though again not very large. The girths of the regulated trees do not differ significantly from those of the modified leader winter pruned trees but are somewhat larger in the cases of Worcester, Allington and Edward. The winter pruned open centres have significantly greater girths than the corresponding modified leaders only for the varieties Edward and Emneth. The summer pruned open centres do not differ appreciably from the summer pruned modified leaders.

Comparing the girths of summer pruned trees with those only winter pruned, it is evident that summer pruning reduces the girth of the trees in all varieties, and this applies to both modified leaders and open centres. Evidently the reduction of leaf surface during the growing season, together with the additional utilisation of reserves occasioned by the renewed growth induced by summer pruning, reduces the amount of food materials available for radial growth of the stem. The reduction in girth is not very large, 5% or 6% compared with the winter pruned trees, but it must be remembered that the period of treatment, 9 years, is only a small fraction of the life of the trees and it is evident that over a long period, repeated summer pruning will undoubtedly result in relatively small trees.

The difference between the regulated trees, receiving very light winter pruning, and the open centres and modified leaders receiving more drastic winter pruning, is not so marked as that between comparable winter pruned and summer pruned trees. This indicates that a relatively heavy pruning may be carried out in the dormant season without producing the same reduction in size as is brought about by the removal of leafy shoots in the growing season. It may be said then, that whilst trees which are practically unpruned are in some cases slightly bigger than pruned trees, a reasonable winter pruning, whether designed to produce open centres or modified leaders, does not seriously reduce the size of the tree. Summer pruning, on the other hand, certainly does so.

It is clear that removal of leafy shoots removes both the material and the mechanism for increase of dry weight, a fact which is well illustrated by the observations of Tubbs (10) on the tea plant, with which, in certain situations, continual pruning of leafy shoots resulted in depleted carbohydrate reserves in the roots and consequent die back of branches.

Chandler (1) noted that shortly after summer pruning, apple trees had paler leaves than comparable winter pruned ones, which he attributed to the presence of young leaves on new growth. The summer pruned trees in our experiment can be readily recognised by the much paler green foliage compared with the winter pruned trees, a condition which persists throughout the season and cannot therefore be due to new leaves. It is suggested that repeated summer pruning reduces the carbohydrate reserves of the trees to such an extent that root activity is diminished and the trees show symptoms of nitrogen deficiency.

Blossom and Fruit Set.

In considering the effects of different pruning treatments it is logical to anticipate that blossom production might be one of the factors considerably affected. The amount of blossom depends mainly on two factors, namely the length of fruiting wood, and the condition of nutrition of the tree. Both these factors are affected by pruning. Almost any kind of pruning will reduce the lengths of shoots capable of bearing fruit buds either in the current year or in subsequent years, whilst in addition, severe pruning may cause buds which would otherwise have developed into fruiting spurs to become vegetative shoots. Pruning, and particularly summer pruning, may seriously modify the nutritional status of the tree, as already pointed out, by disturbing the balance between growth and reserve materials.

It need hardly be said that in the present experiment, though the five pruning treatments were very different, they were all *good* treatments in that all were carried out with the object of producing well-formed trees of each particular type with a maximum fruit production capacity under the particular conditions prevailing. None of the treatments therefore more than another involved the deliberate reduction of fruiting wood and in all cases due regard has been paid to the balance between growth and cropping, this being controlled by suitable manuring as well as by pruning.

Each year in May, counts were made of the total number of blossom trusses on each tree. These have been recorded graphically for the varieties Cox and Worcester in Figs. 3 and 4, in which each point represents the mean for the twelve trees of a particular treatment. Treatment I, in which only complete branches were removed and this only when necessary, approximates to a condition of natural growth and blossoming unmodified by pruning treatment, and, in fact, the blossoming of these trees is so little reduced by pruning, and so little subject to the annual fluctuations associated with the other pruning treatments, that it has been possible to draw ideal curves which pass through most of the points. In 1935 practically all the blossom was destroyed by frost before the count was taken, which accounts for the low value of this point on the

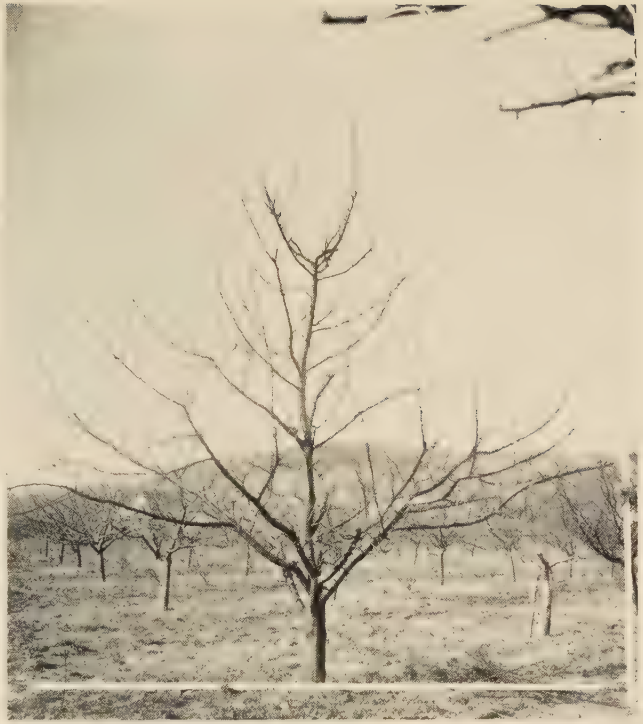

FIG. I. Cox's Orange Pippin. Modified Leader in Winter, 1934.

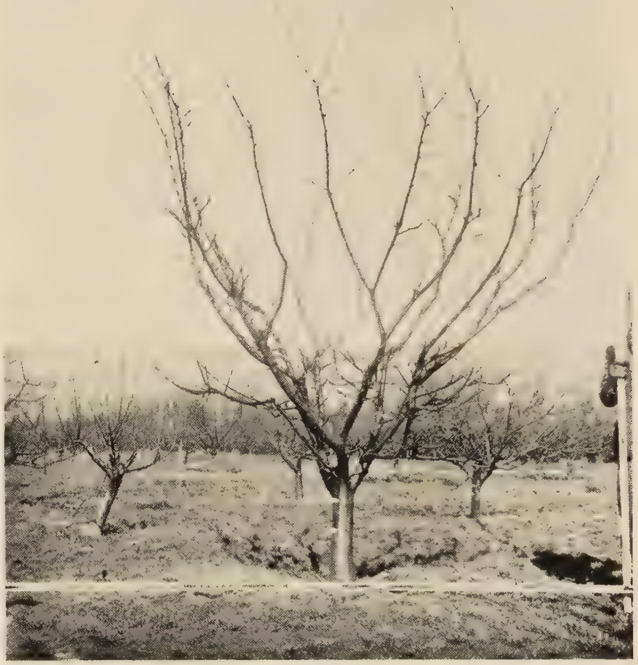

FIG. II. Cox's Orange Pippin. Open Centre in Winter, 1934.

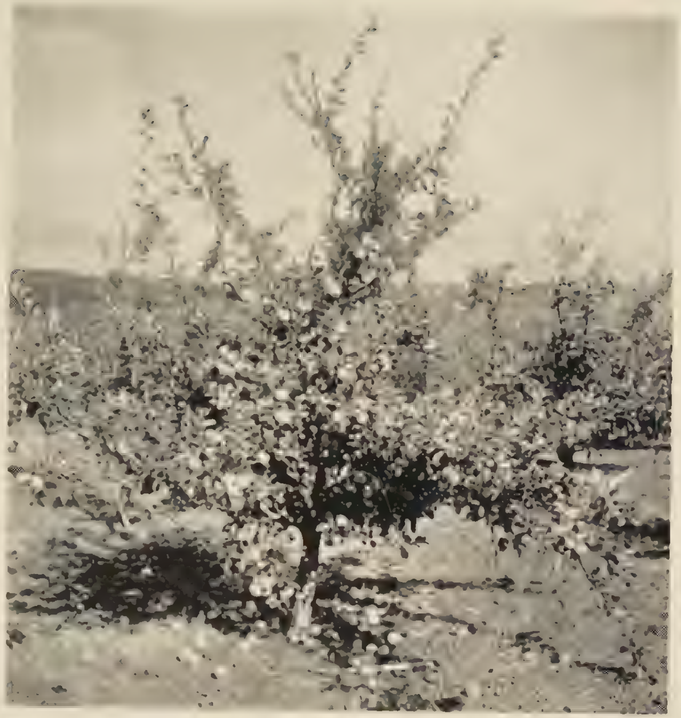

Fig. V Allington Pippin Modified Leader in Summer, 1934

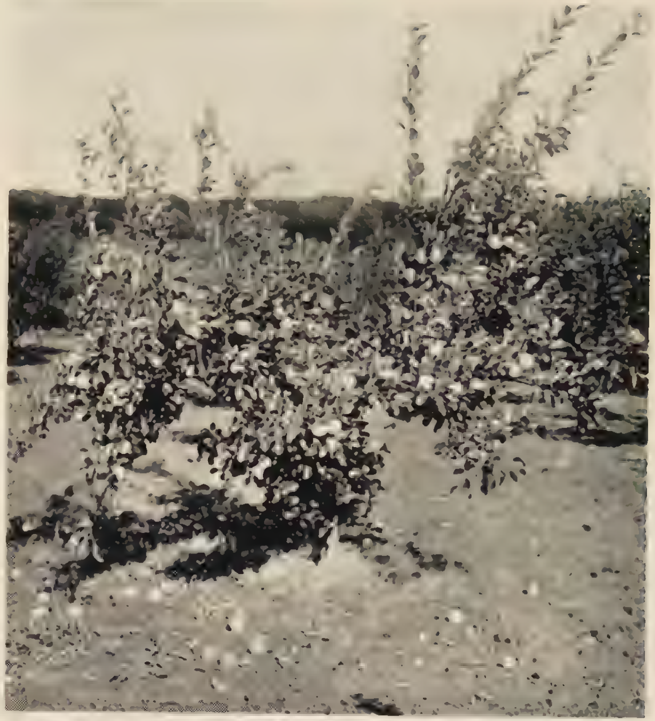

Fig. VI Allington Pippin Open Centre in Summer, 1934

curves. This is the only anomalous point in the case of the Cox variety, but with Worcester the values for 1934 and 1937 are also very low, a fact which cannot be accounted for by any known circumstances of weather or treatment. Evidently the Worcester trees are affected in this respect by some factor which does not operate in the case of the Cox trees. The latter variety seems to be unique as regards the amount of blossom produced in 1937, since Allington, Edward and Emneth under the regulated treatment as well as Worcester produced very small amounts compared with 1936. The dotted curves may be taken as representing the natural potential fruiting capacities of the two varieties, and it is interesting to note that the two curves are almost exactly superimposable. In other words, however much the potential crop is reduced by non-setting of fruit, June drop, windfalls and so forth, these two varieties both started each season with the same number of blossoms or potential fruits and this equality has persisted through the first ten years of their life. This is a remarkable fact in view of the differences in the growth habits of the two varieties, and that most of the blossoms of Cox are borne on spurs, whilst Worcester produces approximately equal numbers of spur, terminal and lateral blossoms. It is clear that the remaining four treatments all have a pronounced effect on blossom production, due partly to reduction in the size of the trees but mainly to the removal of shoots which would otherwise have borne blossom buds. The graphs illustrate in a striking manner the drastic effects of even an orthodox pruning treatment on the amount of blossom. Compared with the large reduction brought about by any of the treatments II, III, IV and V, the differences between them are relatively small. It appears, however, that in the case of Worcester (see Table IX) the total blossom production of the summer pruned trees is frequently greater than that of trees only winter pruned and particularly so in 1937 (see Fig. 3). Moreover, when the blossoms are classified into spur, terminal and lateral categories (Table VIII), it appears that treatments III and V give consistently more spur blossoms than treatments II and IV respectively, *i.e.* the number of spur blossoms is increased by summer pruning. There is also a tendency for the terminal blossoms to be reduced by treatments III and V, but the lateral blossoms do not show consistent differences. So far as the Worcester trees are concerned then, it may be said that on the whole summer pruning has increased blossom production. Spur blossoms are markedly increased, generally at the expense of terminals but in some cases in excess of the reduction in terminals or laterals.

TABLE VIII.

BLOSSOM CATEGORIES.

WORCESTER—Trusses per Tree.

Treatment.		1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
I	Spur	1.4	9.8	6.3	22.1	57.8	116.9	92.4	63.9	495	133
	Terminal	4.7	4.8	10.8	14.4	41.3	64.6	70.3	47.7	476	277
	Lateral	3.0	12.8	24.1	39.8	14.9	172.3	70.1	0.8	481	13
II	Spur	1.8	3.7	2.4	15.8	48.9	50.3	50.9	36.6	233	164
	Terminal	4.6	4.1	7.8	7.3	24.7	38.9	40.1	29.5	176	172
	Lateral	1.3	3.9	8.3	27.3	8.9	68.7	42.0	1.1	147	9
III	Spur	1.1	5.3	4.3	24.4	60.5	71.8	103.6	83.4	346	385
	Terminal	5.2	4.0	7.5	8.9	23.5	21.8	22.4	17.1	89	94
	Lateral	2.4	9.2	13.3	33.5	12.5	56.5	19.7	13.7	108	27
VI	Spur	2.3	5.3	5.3	14.0	49.8	51.8	33.8	41.0	151	89
	Terminal	4.4	4.8	7.7	8.3	21.6	24.3	24.3	27.9	158	166
	Lateral	3.5	13.4	17.1	32.5	8.9	39.4	35.6	7.8	153	11
V	Spur	1.3	5.8	7.7	24.0	63.5	58.2	60.4	95.8	286	293
	Terminal	4.8	5.0	8.3	7.8	24.4	23.3	16.4	17.7	79	81
	Lateral	3.6	10.8	11.2	32.5	4.6	24.1	19.9	13.3	79	23

COX—Trusses per Tree.

Treatment.		1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
I	Spur	0.6	9.9	9.6	69.5	107.6	264.5	478.4	154.3	1029	1999
	Terminal	0.5	0.8	1.2	2.3	2.8	16.8	29.4	3.75	53	21
	Lateral	0.5	3.8	0.6	10.2	0.1	11.4	97.8	0.3	48	9
II	Spur	0.7	6.9	6.0	75.0	95.0	89.5	182.9	93.8	464	910
	Terminal	0.3	1.0	1.3	3.0	4.2	26.3	24.4	10.3	41	26
	Lateral	0.5	10.6	0.4	2.8	0.3	2.3	68.0	3.3	61	0
III	Spur	0.5	7.6	8.2	65.0	107.8	28.5	190.9	94.1	354	909
	Terminal	0	0.6	1.5	4.4	3.5	6.7	14.0	8.5	27	22
	Lateral	0	5.8	2.8	1.6	0	0.7	46.7	0.6	15	2
IV	Spur	1.0	11.6	16.1	66.6	120.5	96.8	111.3	69.7	388	759
	Terminal	0.2	1.0	1.5	3.4	4.1	6.6	15.2	10.3	43	31
	Lateral	0.5	10.8	1.0	0.5	0.1	1.0	61.3	1.5	12	4
V	Spur	0.8	10.8	10.3	73.9	85.8	47.4	102.2	85.8	279	917
	Terminal	0.3	0.9	1.4	3.1	4.6	4.7	9.1	10.9	21	22
	Lateral	0.2	8.2	0.8	1.5	0.1	0.3	33.7	1.2	19	2

Summer pruning has not brought about the same changes with Cox's Orange Pippin, since this variety, when unpruned, normally produces approximately 90% of its flower trusses on spurs. An examination of Table VIII, however, shows a definite though not consistent reduction of terminal and lateral blossoms by summer pruning.

It is further evident from Figs. 3 and 4 that when open centre trees are compared with modified leaders, the former have generally more total blossom trusses whether summer-and winter-pruned or winter-pruned only. This applies to both Cox and Worcester, and agrees with the data for crop weights dealt with in a later section. These differences appear more markedly when the blossoms are segregated into the three different categories and are particularly noticeable for the spur blossoms of Worcester in 1936 and 1937.

It is concluded then, that any kind of pruning reduces blossom production very considerably and modified leader pruning has reduced it rather more than open centre pruning. Summer pruning, especially in the case of Worcester, has caused an increase in the number of spur blossoms. Gardner (2) has also noticed a stimulation of spur formation by summer pruning on Wagener, Yellow Newtown and Grimes Apples.

The percentage of blossoms which set fruit under the various treatments are given in Tables IX and X for Worcester and Cox. The figures for total blossom were obtained by calculation from the numbers of flower trusses. In Worcester and Cox the blossoms per truss are usually 5 or 7. The number of trusses were therefore multiplied by an average figure of 6 to obtain the total number of blossoms. The data in the tables give the total blossoms and fruits set per twelve trees for each year. There are considerable annual fluctuations in the blossoms set, due largely to climatic factors. The weather conditions in 1931 and 1934 when the set was good, were very favourable, whilst the very low percentages set in 1933 and 1935 were due to spring frosts in April and May. April 1932 was wet, dull and cool, whilst May was dull and excessively wet, and there were keen frosts on the 5th, 6th, 7th and 8th. April 1933 was generally bright and dry with keen frosts on the 19th and 20th. May was dull and though rainfall was normal the temperature fluctuated considerably and there were cold periods during the early part of the month. May 15th, 1935, was the occasion of a severe frost which reduced the blossom set to zero over wide areas.

TABLE IX.

WORCESTER.—TOTAL BLOSSOMS AND % FRUIT SET.

Treatment.	I.			II.			III.			IV.			V.		
	Total Blossoms.	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*
1929 ..	1974	224	11.35	840	141	16.79	1326	163	12.29	1692	242	14.30	1554	205	13.19
1930 ..	2718	548	20.16	1332	460	34.53	1806	376	20.82	2160	581	26.90	1944	330	16.98
1931 ..	5034	2521	50.07	3864	1700	44.00	4812	1555	32.32	3948	2270	57.50	4440	1611	36.28
1932 ..	7524	1383	18.38	5940	1458	24.55	6372	1432	22.47	5778	1446	25.03	6102	1301	21.32
1933 ..	23742	1217	5.13	11370	210	1.85	9906	207	2.09	8322	169	2.03	6966	122	1.75
1934 ..	16212	11657	71.90	9576	6392	66.75	9618	6112	63.55	6738	4807	71.34	6378	4014	62.94
1935 ..	7422	0	0	4842	0	0	7536	0	0	5514	0	0	8370	0	0
1936 ..	95820	13948	14.56	40014	10228	25.55	35844	7263	20.26	33246	8995	27.06	29322	12254	41.79
1937 ..	27906	5257	18.84	24858	5693	22.90	33348	7124	21.36	19146	6132	32.03	26148	1538	5.88

TABLE X.

COX.—TOTAL BLOSSOMS AND % FRUIT SET.

Treatment.	I.			II.			III.			IV.			V.		
	Total Blossoms.	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*	*Total Blossoms.*	*Fruit Set.*	*% Set.*
1929 ..	1044	178	17.05	1332	358	26.88	930	146	15.70	1680	276	16.43	1428	272	19.05
1930 ..	816	131	16.05	538	128	22.94	828	175	21.13	1338	284	21.20	900	145	16.11
1931 ..	5898	1300	22.04	5814	1773	30.50	4686	1043	22.26	5076	1235	24.33	5652	1851	32.75
1932 ..	7956	556	6.99	7164	723	10.09	7344	712	9.69	8976	882	9.83	6516	774	11.82
1933 ..	21072	886	4.20	8502	526	6.19	2376	202	8.50	7512	513	6.83	3774	341	9.04
1934 ..	43608	17602	40.36	19848	12074	60.83	16608	7381	44.44	13872	6604	47.61	10368	4886	47.13
1935 ..	11394	0	0	7740	0	0	6816	0	0	5868	0	0	7050	0	0
1936 ..	81318	10777	13.25	40746	9465	23.23	26202	4945	18.87	31824	7113	22.35	22992	3308	14.39
1937 ..	146088	14661	10.04	67422	13502	20.02	61602	10520	17.08	57192	11884	20.78	67746	12958	19.13

There is very little consistent difference to be noticed between the effects of the different treatments on fruit set. Regulated pruning gives a somewhat lower percentage set than the other treatments with Cox, but the results with Worcester are irregular. Summer pruning seems to have reduced the percentage set to some extent, but the effect is not always consistent. Modified leader pruning does not differ from open centre pruning in this respect.

Crop Weights.

The weights of marketable fruit for each tree were totalled for the nine successive years 1929-1937 and the mean annual yields per tree calculated. The period in question included the frost year of 1935 in which the whole crop was destroyed, but that year is included in the calculation of the mean yields, since no doubt the absence of crop in 1935 influenced the yield in the following year. Analysis of variance showed that there was no significant difference between similar trees on different blocks, nor were the interactions between blocks and varieties or blocks and treatments significant. On the contrary, the effects of variety and treatment and the interaction between these were highly significant. The relation between variety and treatment and the weight of crop is given in Table XI, the yields being recorded in kilogrammes. Each figure represents the mean annual yield of 12 trees. The data are converted into tons per acre in Table XII in order to give an idea of the relative crop weights on a commercial scale, the trees being planted on the square at 15ft. by 15ft., *i.e.* 193 trees to the acre.

TABLE XI.

Mean Annual Crop Weights per 12 Trees. (Kilos).

Treatment.	*Worcester.*	*Cox.*	*Allington.*	*Edward.*	*Emneth.*	*Total.*	*Mean per Tree*
I ..	140.6	207.3	336.8	90.5	237.6	1012.8	16.88
II ..	107.4	187.5	253.2	100.9	126.8	775.8	12.93
III ..	109.5	137.1	222.6	67.6	183.8	720.6	12.01
IV ..	88.7	153.9	210.8	96.6	187.9	737.9	12.29
V ..	83.0	125.7	222.1	72.9	114.0	617.7	10.29
Total ..	529.2	811.5	1245.5	428.5	850.1	3864.8	
Mean per tree ..	8.82	13.52	20.76	7.14	14.17		

S.E. = 0.449. Sig. diff. = 1.24.

TABLE XII.

Mean Annual Yields in Tons per Acre Over 9 Years.

Treatment.	*Worcester.*	*Cox.*	*Allington.*	*Edward.*	*Emneth.*
I	2.23	3.28	5.33	1.43	3.76
II	1.70	2.97	4.01	1.60	2.01
III	1.73	2.17	3.53	1.07	2.91
IV	1.41	2.44	3.42	1.53	2.98
V	1.31	1.99	3.52	1.15	1.81

It is evident from Table XI that highly significant differences in yield occur between different varieties receiving the same pruning treatment. The relative orders of crop weights for the various treatments are as follows.

TABLE XIII.

Regulated Pruning ..	Allington.	Emneth.	Cox.	Worcester.	Edward.
O.C. Winter Pruned	Allington.	Cox.	Emneth.	Worcester.	Edward.
O.C. Summer and Winter Pruned ..	Allington.	Emneth.	Cox.	Worcester.	Edward.
M.L. Winter Pruned	Allington.	Emneth.	Cox.	Edward.	Worcester.
M.L. Summer and Winter Pruned ..	Allington.	Cox.	Emneth.	Worcester.	Edward.

Evidently Allington is the heaviest cropper to date, with Emneth a not very good second, closely followed by Cox. Worcester is much less prolific, and Edward least of all. Differences due to treatment alone are not so pronounced, those between treatments II. III and IV being too small to be significant. Regulated pruning gives a higher yield with all varieties except Edward. The higher yields are to be expected since the trees are larger and produce more blossoms, but the result does not necessarily mean that "regulated" trees are to be preferred, for the quality of the fruit, a point which will be discussed later, must be taken into account.

A comparison of the yields of winter-pruned and summer-pruned trees shows that summer pruning reduces the weight of crop significantly in the varieties Cox and Edward. The yields are also reduced in the cases of Worcester, Allington and Emneth, but not to a significant extent.

Comparing open-centre trees with modified leaders, Worcester, Cox and Allington have significantly higher yields with the open-centre treatment, the differences being not significant for the varieties Edward and Emneth. Modified leader pruning has given particularly low yields with Worcester, the upright habit and production of terminal blossoms making this variety unsuitable for training to this shape.

Further analyses may be made to compare the yields of summer-pruned open centre trees with summer-pruned modified leaders, and winter-pruned open centres with winter-pruned modified leaders. In the case of the summer-pruned trees, the open centre trees gave a higher yield for the varieties Worcester, Cox and Emneth, the other two varieties showing no significant differences. For trees winter-pruned only, Worcester, Cox and Allington produced greater crops when trained as open centres. The difference between the two treatments is not significant in the case of Edward, whilst for Emneth the yield was smaller for open centre trees than for modified leaders.

TABLE XIV.

Mean Annual Weights of Marketable Fruit (Kilos).

Worcester.

Treatment.	1929	1930	1931	1932	1933	1934	1935	1936	1937
I ..	0.292	0.432	2.829	1.720	4.418	36.882	No Crop	33.298	26.382
II ..	0.241	0.396	2.038	2.216	1.117	21.948	—	24.176	28.538
III ..	0.304	0.479	2.893	3.083	1.427	18.586	—	18.374	37.114
IV ..	0.184	0.257	1.895	2.082	1.046	14.195	—	19.889	27.029
V ..	0.236	0.259	1.480	1.416	0.795	11.563	—	16.559	29.876

Cox.

I ..	0.044	0.705	1.892	2.474	8.807	38.782	No Crop	32.229	70.254
II ..	0.180	1.005	2.139	3.628	5.914	25.695		29.875	72.286
III ..	0.051	1.190	2.614	3.200	2.382	17.470	—	18.374	37.114
IV ..	0.089	1.431	2.577	5.598	4.401	11.949	—	30.325	59.067
V ..	0.047	0.970	2.610	3.180	2.942	11.077	—	10.092	62.317

The production of marketable fruit per tree in successive years, of trees under the different treatments, is given in Table XIV for Worcester and Cox. The trees show a small but progressive increase in cropping from 1929, when the first crop was recorded, to 1933, and until this year the differences between treatments were not very considerable. The regulated trees then took the lead and maintained it until 1936, whilst the summer-pruned trees began to lag behind. The heavy pruning of 1933 does not seem to have affected seriously the fruit production the following year, the 1934 crops being very considerably larger than the previous year. The late spring frost of May 1935 reduced the crops in all cases to zero but it does not seem that this has induced a biennial bearing habit, the 1936 crop being only of moderate size, and that for 1937 being much larger except in the case of the regulated Worcesters. Comparing these results with those for the pruning weights, there seems to be no connection between the weight of pruning wood removed one year under any given treatment and the size of the crop the following year. This of course is as it should be when careful pruning is carried out. The same weight of wood removed by bad pruning might bring about an enormous reduction in crop weight.

As may be expected in the early life of a plantation, cropping has been somewhat irregular, and on three occasions the crops have been reduced by frost so that it has not so far been possible to obtain reliable comparisons of fruit quality and value. In 1936, however, a comparison was made of the relative numbers of Worcester apples occurring in the various size grades for the different treatments, and in 1937 a similar comparison was made for Cox. The data for Worcester are presented in Table XV, from which it appears that the open centre summer pruning treatment resulted in the highest proportion of first grade fruit, 49.18%, though it also produced the greatest proportion of culls, 34.63%, the sizes 2¼in. to 2¾in. being relatively few.

TABLE XV.

WORCESTER.—Size Grades as percentages of Total Yield.

Treatment.	2¾″—3″	2½″—2¾″	2¼″—2½″	*Culls*
I	42.86	27.43	4.00	25.71
II	43.47	27.56	3.46	25.51
III	49.18	14.35	1.84	34.63
IV	37.16	26.71	3.08	33.05
V	36.30	28.93	3.55	31.22

Regulated pruned and open centre trees winter-pruned produced similarly graded fruit, whilst the modified leaders gave rather lower grade fruit whether summer or winter-pruned. Winter-pruned open centre trees gave a higher proportion of first-grade fruit and fewer culls compared with winter-pruned modified leaders. Summer pruning gave rather more first-grade fruit than winter pruning only. Summer-pruning on open centres gave more " super quality " fruit and more culls than winter-pruning, whilst there is very little difference in the correspondingly treated modified leader trees. Taking all the grades into consideration, it would appear that open centre trees winter-pruned only have produced the higher quality crop, having 70% of the crop in the first two grades and only 25% culls. The regulated treatment differs only slightly from this.

In 1937, the most recent cropping year, records were taken of size grades for the Cox crop after the fruit had been in common store till November. These are given in Table XVI as percentages of the total yield for each treatment.

TABLE XVI.

Cox.—Size Grades as percentages of Total Yields.

Treatment.	2¾″—3″	2½″—2¾″	2⅜″—2½″	2¼″—2⅜″	2⅛″—2¼″	2″—2⅛″	*Culls.*	*Rots.*
I ..	0.12	7.22	9.45	23.47	11.33	13.26	30.22	4.93
II ..	1.02	16.22	17.06	30.96	6.72	7.91	17.01	3.11
III ..	0.45	18.97	19.42	30.80	5.80	5.66	17.19	1.71
VI ..	1.60	20.91	22.57	27.10	5.73	4.99	14.05	3.06
V ..	0.25	9.21	23.98	32.24	10.54	8.14	13.31	2.33

It is clear from these figures that regulated pruning produces the greatest proportion of unsaleable fruit, 35% of the yield being composed of culls and rotted fruit. In this repect the modified leader trees have a considerable advantage, less than 16% of the fruit being unsaleable from the summer-pruned trees and only 17% from the winter-pruned trees. These figures compare with 19% and 20% for the open centre summer-pruned and winter-pruned trees respectively. The fruits included in the size group 2¾in.—3in. form a negligible proportion of the yield in all cases, and for practical purposes it is convenient to compare the proportions of crop falling between the dimensions 2⅛in. to 2¾in.*, since these form the bulk of the crop, and include the most valuable sizes from the commercial point of view. The order of treatments is then as follows :—

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* The fruits are actually graded by weight and not measurement.

Modified Leader	winter-pruned	..	76.31%
,, ,,	summer-pruned	..	75.97%
Open centre	summer-pruned	..	74.99%
,, ,,	winter-pruned	..	71.04%
Regulated	.. .. ..	..	51.47%

From these figures it may be concluded that the modified leader trees produce a higher proportion of high-grade fruit than the open centre trees, whilst the regulated treatment results in a crop of much lower grade than either. Summer-pruning has produced rather better fruit than winter-pruning in the case of the open centres, but with modified leaders the amounts do not differ appreciably.

In order to compare the effect of pruning treatment on the colour of the fruit, 200 apples were taken at random from the 1937 crops of Cox for each treatment, except in the case of treatment V where only 189 were taken. The apples were examined individually and awarded marks from 0 to 6 according to the amount of crimson flush. Six marks were given for complete coloration, zero indicating no crimson colour at all. The following table gives the results of this examination.

TABLE XVII.

COLOUR GRADING OF COX'S.*

Treatment.	*Number Examined.*	*Total Marks.*	*% of Possible.*
I ..	200	533	44.42
II ..	200	563	46.92
III ..	200	610	50.83
IV ..	200	554	46.17
V ..	189	547	48.24

* Scores of individual apples are not available for calculation of significant difference.

It appears that fruit from the summer-pruned open-centre trees exhibits the highest degree of colouring, whilst that from the summer-pruned modified leaders comes next. The fruits from the winter-pruned trees are less highly coloured than the corresponding summer-pruned ones, but there is no difference between open centres and modified leaders in this case. Fruit from the regulated trees is poorly coloured compared with the other treatments. It may be concluded therefore that removal of leafy shoots in the summer improves the colour of the fruits, particularly in the case of open centre trees. This is no doubt due to increased insolation of the fruits but may also reflect the low nitrogen condition of the summer-pruned trees. Apart from the effect of summer pruning there is little advantage to be gained as between open centre and modified leader pruning.

To summarise the crop data, it appears that whilst "regulated" trees produce the larger crops the fruits are not of the best grade or colour. As regards the effect of tree shape it is concluded that open centre trees have been generally rather more productive than modified leaders during this early period of their history. The Worcester crops in particular have been much reduced by modified leader pruning, and with this variety, too, it seems that open centre trees gave a bigger proportion of large-sized fruit than modified leaders. With Cox the advantage in grading is slightly with the modified leaders. Summer pruning in most cases has reduced the crop to some extent, though it has tended to increase the size of the fruits, and has definitely improved the colour of the Cox, particularly on the open centre trees.

DISCUSSION.

It is difficult to draw general conclusions from the results presented, because of the varying effects produced by the treatments with different varieties. Certain generalisations nevertheless can be made. So far as winter pruning is concerned, it is true that whatever method is adopted, the effect is to reduce growth and cropping to some extent. Pruning reduces tree size and crop, but these reductions are compensated by an improvement in fruit quality and easier management of the orchard. Summer pruning is an operation which, in the writers' opinion, can well be omitted from commercial practice. Whilst it provides certain advantages in the way of improved fruit colour and increased fruit size, its effects on the tree are definitely devitalising, resulting in smaller trees, reduced root growth and lack of condition in the foliage, besides consuming a considerable amount of time in a busy season. In intensive systems of fruit culture where cordons or closely planted dwarf pyramids are to be dealt with, summer pruning is essential to keep the trees within bounds and to induce fruitfulness by checking growth. In a well-spaced bush plantation, however, the object should be to produce large, vigorous trees capable of carrying heavy crops when they reach maturity, and there should be no question of checking growth and stunting development. In these conditions it is certain that summer-pruning is to be deprecated as possessing more drawbacks than advantages.

From the data presented, it is concluded that open centre trees of most varieties produce larger crops than the modified leaders and take rather less time to prune. This conclusion, however, needs some qualification. It has been already stated that the open centre trees had two years' start on the modified leaders, and drastic changes were necessary to develop as modified leaders, trees which had been started as open centres. This early difficulty has resulted in some cases in rather upright and very much overcrowded lower main branches, a drawback that is only being overcome with difficulty and by somewhat harder pruning than would otherwise be desirable. It must be emphasised also that the close planting distance of 15 feet has proved a considerable handicap to all the trees, but as may be seen from Figs. I and II the modified leaders must have suffered more than the open centres in this respect, since their branches must increase in length horizontally, whilst those of the open centre trees can grow upward without much interference.

The modified leader type of tree possesses certain advantages which cannot be measured in terms of crop-weight or growth measurement. As Roberts (3) and also Swarbrick (4) have pointed out, open centre trees with their upright branches, of necessity have weak, narrow-angled crotches which often collapse under the strain of a heavy crop. The wide-angled crotches of the modified leader on the other hand will withstand almost any load without breaking. Even where actual fracture of the branches has not occurred, it has been found essential in heavy cropping seasons on this plantation to support the branches of all the open centre trees in order to keep them from the ground and prevent them interfering with cultivation, whilst only in rare cases has this been necessary with the modified leader trees. This is well illustrated in Figs. V and VI. It is our experience, too, that modified leader pruning makes spraying and picking easier, advantages which must be weighed against the increased crops produced by the open centre trees in the rather favourable conditions of this experiment.

SUMMARY.

1. Pruning treatments on five different apple varieties are described, designed to compare the performance of winter-pruned and summer- and winter-pruned modified leader and open centre trees with "regulated" trees.

2. The weights of wood removed by winter pruning are compared for each treatment, and it is shown that modified leaders take longer to prune than open centres. Summer-pruning reduces the time spent on winter-pruning.

3. The influence of pruning treatment on tree size is discussed. Any kind of winter-pruning reduces tree size to some extent, but the addition of summer-pruning reduces size considerably more.

4. Blossom production is very much reduced by any kind of winter-pruning. Summer-pruning increases the proportion of spur to terminal and lateral blossoms.

5. Crop weights for different varieties and different pruning treatments are compared. Open centre trees generally produce rather bigger crops than modified leaders. Open-centre Worcesters have better grade fruit than modified leaders, but the reverse is true for Cox's Orange Pippin.

6. Summer-pruning improves both colour and size of the fruits especially on open centre trees.

7. It is noted that modified leader trees have stronger branches and provide advantages in regard to facility of management.

LITERATURE CITED.

(1). Chandler, W. H. "Results of Some Experiments in Pruning Fruit Trees." *Cornell Univ. Agric. Expt. Sta. Bull.* 415. 1923.

(2). Gardner, V. R., Magness, J. R. and Yeager, A. F. "Pruning Investigations." *Oregon Agric. Expt. Sta. Bull.*, 139. 1916.

(3). Roberts, R. H. "The Modified Leader Tree." *Univ. of Wis. Agric. Expt. Sta. Bull.*, 354. 1923.

(4). Swarbrick, T. "The Aims, Advantages and Method of Building a Modified Leader Tree." *Sci. Hort.*, VI, p. 299. 1938.

(5). Tubbs, J. R. "On the Growth and Carbohydrate Supply of the Tea Plant after Pruning." *J. Pom. and Hort. Sci.*, 14 (4) 317. 1937.

NOTES ON SOME METHODS OF STAKING AND GUARDING ORCHARD TREES AND THEIR COSTS.

By T. SWARBRICK.

The staking and guarding of standard trees in the farm orchard are rarely given the care and attention which they deserve. Good standard trees, costing from 3s. to 7s. 6d. each, deserve to be well staked, and to be guarded against the ravages of rabbits and farm stock. Unfortunately many of the home-made cheap constructions used are either not effective, or if effective, do not remain so for more than two or three years. The farmer should be prepared for an expenditure of about 3s. per tree as the cost of staking and guarding a standard orchard tree. An establishment cost of 10s. per tree, or about £20 per acre, may be regarded as sufficient to purchase good trees and employ a durable staking method. Where particularly difficult conditions prevail it may be necessary to increase the figure a little.

The present paper is based on experience gained during the last ten years, both at Long Ashton and in the West Country generally. Its special purpose is to illustrate the general principles of staking and guarding that must be recognised and to give some approximations of the costs of various methods. There are, of course, many variants of the methods described in this paper which are often determined by local supplies of timber and by tradition.

Timber for Stakes.

The kind and quality of timber employed for stakes requires special emphasis. Farmers are frequently tempted to use saplings or the tops of larch or spruce poles because they are handy and available in the locality at what appears to be a cheap rate. With the single exception of oak, and possibly chestnut, it is not advisable to use green timber since, being mainly sap wood, it rots quickly. If such timber is employed, it should not be less than 4in. diameter at the butt end and should be first peeled and pointed, and then creosoted before use. The two best and cheapest sources of stakes are the saw mills of large country estates and those in large cities which make a speciality of cutting up the ends of joists, etc., that are left over from large building contracts. In Bristol, for example, there is at least one such firm which can give very satisfactory quotations for stakes made from this class of timber. This timber is often cut from ends of Canadian and Baltic red wood, and when well creosoted has a satisfactory life. Excellent stakes are often available in the region of sea ports from the breaking up of old ships. Deck planks make excellent stakes.

As the result of observations on sources of timber farmers are strongly advised to search their localities for suitable and durable stakes rather than employ anything that happens to be convenient. More young trees are lost from damage by rabbits and stock as the result of faulty or inadequate staking methods than from any other cause and poor stakes contribute largely to this loss. In remote districts green timber of sorts may be the only kind available, in which case every effort should be made to prepare the stakes a year in advance, storing them during summer in a dry place and then standing the butt ends in boiling creosote for at least 12 hours. A simple boiler is easily constructed from a tank set on bricks or stones so as to raise it sufficiently above the ground to allow of a fire beneath it.

Throughout this paper costs have been based on the assumption that everything must be bought in the ordinary way, and through the normal channels of trade. Where materials are produced on the farm or estate or can be purchased in bulk through trade association the costs would be reduced accordingly.

Description of Methods.

Method 1. (*Fig.* I).

This is one of the best and most durable methods that can be employed, although by no means the most expensive. The materials used consist of one railway sleeper sawn in half lengthwise and old barrel staves. The material is in fact the most durable that it is possible to obtain in the ordinary way. It is a two-stake method, the stakes being set at about a yard apart. The half sleepers being oblong in cross section, should be set so that the widest side faces the tree. This allows of the maximum room for tree growth, and the barrel staves are also fastened bulge outwards for the same reason. The lower staves are put sufficiently close to each other to prevent the entry of rabbits. While the upper ones can be spaced at any distance desired. The tree is tied to a brace across the top. The cost of this method is about 5s. 6d., and its estimated life is twelve years. In fact, at the end of twelve years the parts of the sleepers above ground level will still make good fencing posts, and the barrel staves will be good enough to use again for another tree guard.

The main advantages of this method are its effectiveness, its durability and its neatness. It provides protection against all forms of farm livestock, and is especially recommended where gaps in established orchards are being filled with young trees. In such cases the cost of providing adequate protection is not such a serious consideration as when a whole new area is being planted. The structure is simple to erect and avoids the use of wire netting and barbed wire, the latter being a very important point in those cases where valuable stock is allowed to run in the orchards.

Examination of the tree for the removal of side shoots is also simple, since for this purpose it is only necessary to remove one or two staves on one side. Furthermore digging the ground round young trees protected in this way is easy since only a small area is actually occupied.

This method is recommended where neatness, durability and effectiveness are the main considerations.

Method 2. (*Fig.* II).

This is a single stake method and as illustrated in Figure II combines economy with reasonable effectiveness and durability. The materials used consist of a single rough sawn post, a 6 ft. length of heavy gauge wire netting, large staples and the necessary tying materials.

The actual size of the post must be governed by the kind of wood from which it is made. If made from larch or spruce it should be at least 2¾in. square, whereas if made from ash or oak it can be 2½in. square. Ordinary 3 by 2 quartering serves very well as posts, provided it is reasonably free from knots and is pressure creosoted prior to use. The post must be long enough to reach to the head of the tree and have sufficient hold in the ground to make it firm. Since in any single stake method all the strain falls on the one post, this latter point is of great importance. Normally the post should be at least 8ft. 6in. long when pointed, and since stakes are often shortened in sharpening, it is important when ordering to stipulate their length when pointed. The cost of such posts is approximately 1s. to 1s. 3d. each, depending upon quality.

The importance of using sufficiently long stakes is emphasised by Fig. III, which shows a very common fault in the staking and guarding of orchard trees, namely the use of short stakes. It was mentioned above that when finished the stake should extend up to within a few inches of the lowest branch (Fig. II). When tied to short stakes trees frequently break across at the top of the stake, and are very easily blown over and way from the prevailing wind.

The question of short stakes is of particular importance where trees are being planted on a hill side. In such cases the stakes must be longer than those used for trees on level ground, since they should be put on the lower side of the tree so as to get a firmer hold on the ground. In the case of very steep slopes stakes may have to be a foot longer than would be required for the same trees on level ground.

The tree is fastened to the stake either by one of the specially manufactured ties such as the one shown in Fig. II, or more commonly by strips of old bicycle tyres (see Fig. III). Metal, rubber-lined tree ties are a modern refinement and, while they are satisfactory, they are expensive. The outer covers of bicycle tyres make excellent and economical tree ties when cut up into strips about 2 inches wide. Old tyres can be obtained from cycle shops for a few shillings per hundred. The method of tying is to fasten one end of the strip of tyre to the back of the post by means of a large headed nail. The strip is then passed forwards between the tree and the stake, round the front of the tree and back again between the tree and the post to the other side of the post. The whole thing is drawn reasonably tight and the loose end fastened down by a second nail. The strip of bicycle tyre when in position makes a figure 8 with the post in one loop and the tree in the other. A pad is thus formed between the tree and the post which prevents rubbing. The bicycle tyre has sufficient elasticity to allow of normal growth of the tree stem for several years. It should be examined and if necessary cut and renewed once every two or three years. It is important to make the top tie at the top of the stake since tying at some distance from the top loses so much effective height. It is advisable to trim the top of the post with a sharp knife before tying the tree. A second tie about half-way between ground level and the top of the post is advised.

A piece of 1⅝in. mesh wire netting 2ft. wide and 6ft. long and made from 15 gauge wire formed into a cylinder by fastening it to the back of the post, provides the protection against rabbits and stock.

This wire netting is not of standard size or gauge but can be obtained at a reasonable price from large wholesale merchants who get it specially made. Its strength is derived from the fact that it is made from 15 gauge wire and is woven with a $1\frac{5}{8}$in. mesh. Wire netting is normally made from either 19 or 20 gauge wire.* The netting should be bought in rolls two feet wide and cut off in 6ft. lengths. Some farmers still buy their wire netting in rolls 6ft. wide and cut it off in 2ft. lengths, but this involves much more work in cutting up and provides a rough edge along the back of the post. The former method, however, provides a self-edge along the back of the post, which facilitates both ease of erection and subsequent maintenance. The wire should be fastened to the post by means of large staples. These should on no account be driven home since it is then very difficult to remove the wire netting without serious damage to the post and wire. When the staples are left slightly protruding they are easily drawn out by pincers, and the wire netting removed when necessary.

The cost of a structure erected by this method is from 2s. 6d. to 2s. 9d. per tree, and its estimated life is from 6—8 years. It cannot claim anything like the same rigidity or durability as that shown in Fig. I, but it costs only about half as much. The method is recommended for general use particularly where farmers are planting out from thirty to forty trees and where mature cattle can be kept out of the orchard for a number of years. It is, in fact, the best all round economical single stake method.

There are numerous modifications of the single stake method, due chiefly to differences in the size of the stake and the quality of the wire netting, or to the addition of barbed wire as a further means of protection against cattle. Variations in the quality of the stake range between the use of half sleepers such as those used in Method 1, described above, and a rough green sapling taken from the wood and used without either peeling or pickling in creosote. The cost may be kept low by using cheap wire netting but the effectiveness of the structure is impaired. In some cases several turns of barbed wire are wound round the outside of the wire netting cylinder as a further protection, particularly against horses and cattle. Since all the stress falls on to one post it seems false economy to reduce either the strength of the post or the quality of the wire netting below the limits set out above.

Method 3. (*Fig.* IV).

Fig. IV shows a typical example of the rough and ready methods adopted with modifications by many farmers. Its only claim to consideration is that its cost is mainly for wages with but little capital expenditure on materials. The cost of the posts arises mainly from the wages spent in cutting them from the hedges or woods. Second-hand wire is frequently used in an attempt to reduce costs.

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* Since preparing these notes the cost of wire netting has been advanced, and due allowance must be made for this fact in all costs.

The materials used comprise three posts made of green unpeeled saplings, a small piece of wire netting and about 30ft. of barbed wire. Even the most casual observer must realise the roughness of this method. On the other hand, it certainly gives protection from cattle and sheep while it lasts, but it constitutes a constant menace to the limbs of farm stock grazing in the orchard.

The cost of a structure of this kind works out at 2s. 7d. or about the same as that of Method 2 using a single creosoted stake. Its estimated life, however, is not more than 4 or 5 years, which compares unfavourably with a life of 8 to 10 years in the case of Method 2. Many modifications of this method are to be found in various parts of the country. In some, the wire netting is replaced by a bundle of brush wood tied round the bottom of the tree. This method renders cultural attention to the tree difficult, and is not recommended.

Method 4. (*Fig.* V).

Fig. V shows a typical three-stake construction. The materials used are three larch poles, each about 8ft. long and 3in. diameter at the butt, a 36ft. run of sawn larch, a small piece of wire netting and the necessary tying materials. In the case illustrated the timber was obtained from an estate yard and was employed without any preliminary preservative treatment. The cost of creosoting would have been about 1s. 6d. extra.

This method is a common one in Monmouth and in fact anywhere where timber of the pit prop type is available. The method of erection is simple, the three posts standing at the points of an equilateral triangle with sides about 2ft. 6in. long. Protection from rabbits is afforded by a small collar of wire netting placed round the tree stem, inside the wooden guard.

This method is actually the most expensive of those described in this paper, the total cost amounting to 7s., of which 6s. is for timber alone. Furthermore, the structure has an estimated life of not more than 6—8 years owing to the use of unseasoned and uncreosoted timber. The use of sawn creosoted posts would have been somewhat more expensive but would have added several years to the effective life of the structure.

This method does not allow of much modification except in the calibre of the timber employed. It is only a little more effective and certainly no more durable than the single stake method described earlier, which costs only about one third as much. It is not so durable or effective as Method 1, which costs about 2s. less. It is, however, easy to see how the method came into extensive use in localities where the special type of timber is available due to pit timber being cut on the farms or estates.

Method 5. (*Fig.* VI).

This is another two-stake method. The materials used are two rough-sawn, creosoted posts, two 6ft. lengths of wide mesh wire netting, and six battens—old barrel staves for preference. This structure differs from that shown in Figure 1, mainly in that it employs lighter and less expensive posts and has wire netting sides instead of wooden ones.

The total cost of this method is 4s. 7d., which is about 1s. cheaper than that shown in Fig. I. The method of erection is somewhat similar. Care must be taken to set the two posts at the correct width of the wire netting, which in this case can be ordinary 19 or 20 gauge $1\frac{5}{8}$ or $2\frac{1}{4}$in. mesh of either 18 or 24 inches wide. The wire netting should be fastened by large staples, which should not be driven home so as to facilitate the removal of one side should this be necessary. This guard covers but little area and thereby allows the trees to be kept dug without much difficulty.

Conclusion.

The choice of a staking and guarding method should always be a matter for careful consideration. Good trees deserve to be well planted, staked, and protected. Poor trees on the other hand are not worth planting much less staking and guarding. It does not always follow that the prevailing local method is either the best, most economical or most satisfactory. A case in point is the use of unpreserved larch timber in the construction of Method 4. It would be better to abandon this traditional three-stake method, and employ one with two stakes of larger dimensions. A more lasting structure would be obtained for the same expenditure.

These notes are intended to draw attention to several staking and guarding methods that may be employed. Individual preference and initiative will no doubt suggest improvements or adaptations to local conditions.

Summary.

Five methods of staking and guarding farm orchard trees are described in detail. The costs of construction are set out on the basis of local costs in the Bristol area. Stress is laid upon the use of good timber. Timber such as that used for pit props is rarely satisfactory unless it is previously dried, peeled and pressure-creosoted. Local and traditional methods are not necessarily the best or cheapest.

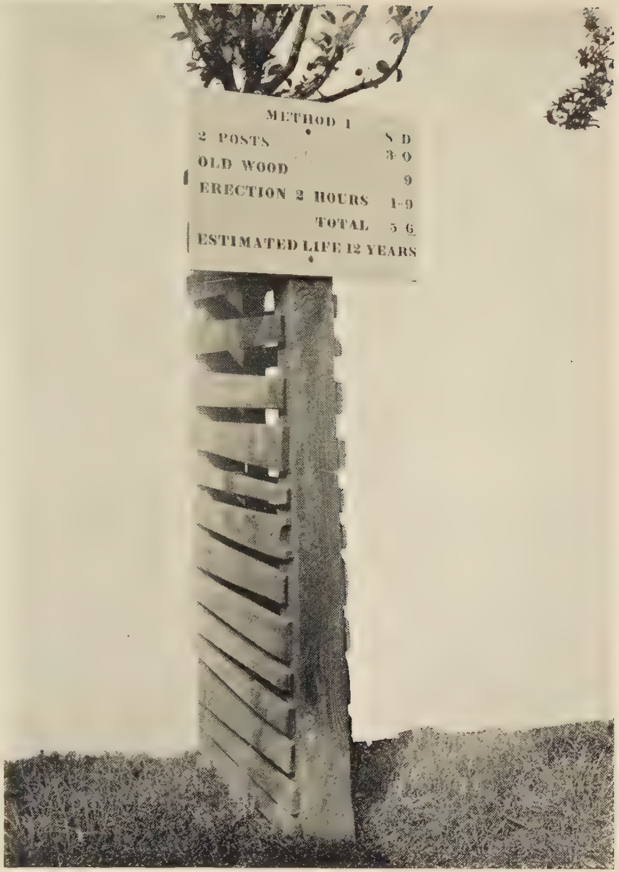

FIG. I.
A neat, durable, and economical two-stake tree guard.

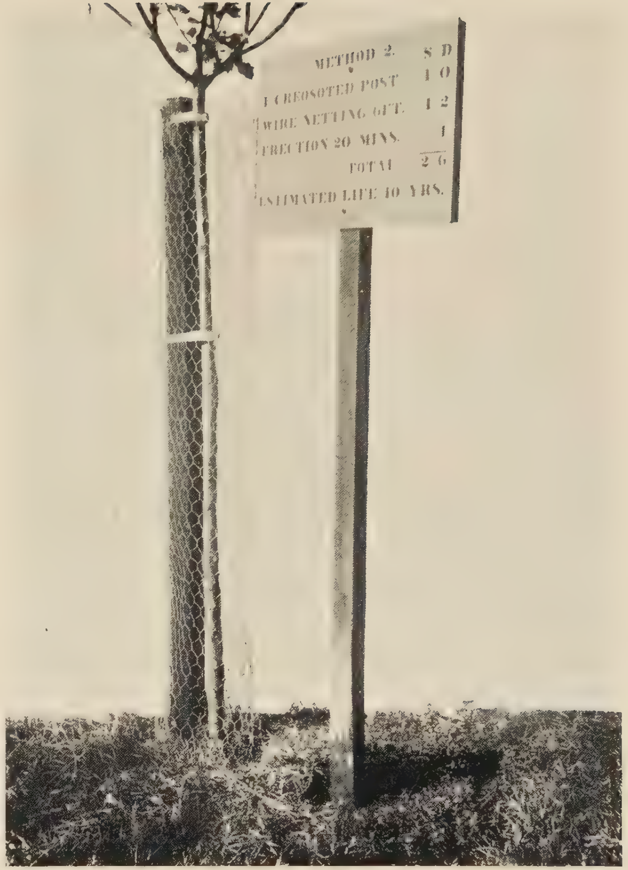

FIG. II.
An efficient and economical single stake tree guard.

COMBINED WASHES.

PROGRESS REPORT.—IV.

THE PHYTOCIDAL PROPERTIES OF PETROLEUM OIL SPRAYS ALONE AND IN COMBINATION WITH LIME-SULPHUR.

By **H. G. H. KEARNS, R. W. MARSH** and **H. MARTIN.**

During the 1937 season, attention was directed mainly towards the employment of oil emulsions as constituents of combined washes. The field work recorded in earlier Reports (1, 2, 3) and laboratory investigations described elsewhere (4) have indicated that of the two general types of supplements, (1) the water-soluble spreaders, and (2) the oils, of potential value in such washes, the latter are superior in respect of their effect on the retention and penetration of the sprays and on the tenacity of the spray residues. On the other hand, the usefulness of the oils is limited by their cost and phytocidal tendencies. The latter aspect is therefore the main subject of the present report.

The experiments upon petroleum oil-lime sulphur combined sprays recorded in previous Reports (1, 2, 3) have justified their adoption in the routine spray programme provided that (1) the varieties sprayed are tolerant of sulphur, (2) sulphite lye is used as the emulsifier of the oil and (3) the petroleum oil is of a high degree of refinement. Of the suitable oils readily available before 1936 in this country, all were acid-refined and of unsulphonated residue above 95 per cent. In 1936, the first samples of solvent-refined oils were secured and, as it was reported that these oils would probably be considerably cheaper than acid-refined oils of similar unsulphonated residue, spray trials were undertaken in 1937. The objects of these tests were to determine (1) whether the general correlation between phytocidal properties and the degree of refinement as measured by unsulphonated residue established for acid-refined oils held for solvent-refined oils; (2) the suitability of solvent-refined oils for application in combination with lime sulphur or to foliage already bearing a lime sulphur deposit. The trials were carried out principally on apples, but experiments were also continued on the use of oil emulsions on plums, and of lime sulphur-oil emulsion mixtures on black currants.

EXPERIMENTAL.

The characteristics of the oils used are given in Table I. For the preparation of the sprays the oils were milled with 20 per cent. sulphite lye (60° Tw.) to stock emulsions containing 67 per cent. by volume of oil. The experimental sprayings were confined to the periods at which phytocidal properties are of major importance in the choice of an oil, namely, the green flower and petal fall stages for apples, the tight cluster stage in black currants and the petal fall stage for plums.

TRIALS ON APPLES.

A. Green-flower Application.

Two trials were made, one upon young, and the other upon established trees.

Long Ashton. (i) Cox's Orange Pippin.

The effects of the application of various oil sprays at the green-flower stage were examined upon five-year-old trees of the variety Cox's Orange Pippin, interplanted within the rows with Boskoop Giant currants. Five trees were used for each spray. The sprays were applied in heavy amounts by means of a hand sprayer on April 26th, in fine sunny weather, when the blossom buds were in late green-flower stage. Those which contained 5 per cent. by volume of oil were also applied to neighbouring trees which had received a green-flower 3 per cent. lime sulphur spray on April 23rd. The underplanted currants in all cases were thoroughly drenched with spray.

Observations upon spray damage were made from time to time and are exemplified by the following notes made on April 30th and later at the end of May.

TABLE I.

Characteristics of Oils Employed.

	L. 6.	L. 7.	L. 8.	L. 9.	L. 10.	P. 3.	P. 23.	P. 24.	P. 25.	P. 26.
Sp. Gr. (60°F.)	0.864	0.868	0.840	0.849	0.853	0.875	0.866	0.873	0.884	0.900
Viscosity, secs. Redwood at 70°F.	127	145	119	97	78	157	118	145	208	159
Boiling Range :—										
90% by vol. distils above ..	323	341	370	335	318	326	350	345	368	343 °C.
50% ,, ,, ,, ,, ..	357	370	384	377	347	362	370	374	390	373 °C.
20% ,, ,, ,, ,, ..	—	—	398	394	374	—	—	—	—	399 °C.
Unsulphonated residue, % by vol.	98	98	96	93	92	82	88	85	74	70
Method of Refining	Acid	Acid	Solvent	Acid*	Acid	Acid	Solvent	Acid	Acid	—

* Of straw colour and not filtered.

TABLE II.

Observations upon Effects of Oil Sprays Applied to Cox's Orange Pippin at Green Flower Stage.

Ref.	*Refinement.*	*U.S.R.*	*Remarks.*
L. 6	Acid	98	No visible damage to flower buds or foliage.
L. 7	Acid	98	No visible damage to flower buds or foliage. No increase of foliage damage on trees sprayed 3 days previously with 3% lime sulphur.
L. 8	Solvent	96	Similar to L.7.
L. 9	Acid	93	do.
L.10	Acid	92	do.
P.23	Solvent	88	Slight bronzing of a few leaves, no other signs of phytocidal action.
P.24	Acid	85	Similar to P.23.
P. 3	Acid	82	Obvious scorching of leaves; younger leaves gradually assumed translucent appearance.
P.25	Acid	74	Marked bronzing and translucency of leaves, many of which were shed.
P.26		70	Similar to P.3.

The results of the trial pointed to a satisfactory correlation between phytocidal action and unsulphonated residue, irrespective of the acid or solvent method of refinement of the oil. Damage was obtained only with oils of unsulphonated residue below 90 per cent.

(ii) Mixed Apple Varieties.

A block of 100, large 16-year-old bush trees of the varieties Annie Elizabeth, Early Victoria, Newton Wonder, Allington, Edward VII, Lord Hindlip, Crimson Cox and Coronation was numbered from west to east in ten rows, each row including one or more trees of every variety. These rows were treated on April 23rd, as shown below, each sprayed tree receiving approximately 6 gallons of wash.

Row	1.	Unsprayed.
,,	2.	7½ per cent. emulsion (5 per cent. oil) L. 6 and 3 per cent. by volume lime sulphur.
,,	3.	ditto ditto L. 7
,,	4.	ditto ditto L. 9
,,	5.	Unsprayed.
,,	6.	As in Row 2, but oil P.25
,,	7.	ditto ditto P. 3
,,	8.	3 per cent. by volume lime sulphur.
,,	9.	As in Row 2, but oil L. 8.
,,	10.	3 per cent. Grade A tar oil emulsion (2 per cent. oil) and 3 per cent. by volume lime sulphur.

All the oils were emulsified with 20 per cent. suphite lye. The combined wash of tar oil emulsion and lime sulphur was included in the trial to ascertain the extent of its phytocidal properties, more especially as a wash of this type had been suggested as a means of controlling Apple Blossom Weevil. Tar oils have, generally, no unsulphonated residue and therefore would be expected to cause very extensive injury even at low concentrations.

At the time of spraying, the flower bud development on the principal varieties was as follows :—

Allington Pippin, Lord Hindlip	Nearly pink bud.
Early Victoria, Newton Wonder	Mid to late greenflower.
Annie Elizabeth, Coronation, Crimson Cox ..	Very early greenflower.
Edward VII	Bud burst.

The sprays were applied in sunny weather but in a slight breeze which carried spray drift from each sprayed row to the adjacent row on the east.

Observations on spray injury were made at regular intervals during the season. The injuries evident at the end of April and the beginning of May are recorded in Table III. None of the petroleum oil sprays caused any serious damage to varieties treated previous to the mid-greenflower stage. Upon varieties in a more advanced stage of flower bud development, observations were confused to some extent by the effects of spray drift, but there was clear evidence that oils P. 3 and P. 25 were more phytocidal than the oils L. 6, L. 7, L. 8 and L. 9. There were indications that sprays containing the latter oils in conjunction with lime sulphur were less injurious than lime sulphur wash alone, a result which has already been recorded in the case of currants (3).

Spray damage was visible on the trees treated with the tar oil-lime sulphur on the day following the spraying, the flower trusses of these trees being later severely damaged. As the season advanced, however, those flower buds developed which, at the time of spraying, were in the mouse-eared stage and eventually set fruit.

TABLE III.

RECORDS OF PHYTOCIDAL ACTION ON APPLE VARIETIES.

Washes applied—23.4.1937. Examinations on 24/30.4.1937 and later dates.

Row.	*Oil.*	*Lime Sulphur.*	*Early Victoria. Mid to Late Greenflower Stage.*	*Hindlip. Nearly Pink Flower Stage.*	*Newton, Coronation, Crimson Cox. Mid to Late Greenflower Stage.*
1	Nil	Nil	No damage.	No damage.	No damage.
2	L. 6	Yes	Slight sulphur scorch.	Slight sulphur scorch, less evident than on 3.	Very slight leaf damage.
3	L. 7	Yes	No damage.	Slight sulphur scorch.	As 2.
4	Nil	Nil	No damage.	No damage.	No damage.
5	L. 9	Yes	Oil damage just evident.	Negligible oil damage to foliage.	Slight leaf damage.
6	P.25	Yes	Slight oil damage.	Evident oil foliage damage.	Slight leaf damage, greater than 5.
7	P. 3	Yes	Somewhat more oil damage than in 6.	Serious oil damage.	Leaf damage.
8	Nil	Yes	Serious damage, not typical sulphur scorch.	Some sulphur burn, probably negligible.	Leaf damage.
9	L. 8	Yes	Some leaf scorch, less serious than on 8.	Negligible damage.	Leaf damage but slight and equal to 5 in parts of the tree not exposed to drift from 10.
10	Tar Oil	Yes	Very severe scorch to leaves of flower bud trusses.	Very severe scorch of flower bud trusses.	Very severe damage to leaves of flower bud trusses.

B. Post-blossom Applications.

(a) Petal-fall.

Long Ashton. (i) Dessert and Culinary Varieties.

A considerable acreage of dessert and culinary apples was sprayed during the last week of May and early June with a wash at petal fall for the joint control of Apple Sawfly, Red Spider and Apple Scab.

The formula of the wash was as follows :—

1 gal. Petroleum oil emulsion (= 0.67 gal. oil).
1 gal. Lime sulphur.
8 fluid ozs. nicotine.

made up to 100 gal. water.

Three grades of petroleum oil were applied, two acid refined, L. 6 and L. 9, and one solvent refined, L. 8 ; all were emulsified by 20 per cent. sulphite lye solution.

The injury produced by the washes was negligible, though the oil L. 9 tended to cause slightly more damage than the other two oils. In many instances an appreciable amount of injury occurred on sulphur-sensitive varieties, and it was evident from these and other outside trials that, at the petal fall stage, the sulphur sensitivity of the variety was increased by the oil emulsions.

The control of Apple Sawfly, Red Spider and Apple Scab was satisfactory. The control of Red Spider on some large Bramleys Seedling trees was particularly outstanding, although it should be noted that in many plantations it might be necessary with this variety to omit the lime sulphur from the petal fall wash in order to avoid appreciable foliage damage.

(ii) Worcester Pearmain.

Petroleum oil emulsion has been shown to be more efficient as a penetrant than water-soluble wetters (3), and its use in combination with nicotine is therefore advocated in Sawfly control. When it is desired to combine Sawfly control with treatment against Scab, lime sulphur is included with the oil emulsion-nicotine wash. Previous experiments, however, have suggested that the combination of lime sulphur with petroleum oil at the post-blossom stage might lead to some reduction of crop. Data were also required on the relative efficiency of oil emulsions and water-soluble wetters as supplements to lime sulphur for the control of Apple Scab. The following trial was accordingly carried out at Long Ashton.

The trees used for the trial were of the variety Worcester Pearmain, planted in 1920 in twelve rows, running north and south, and each containing eight trees. Each of the twelve rows was on a different rootstock. The whole plot of 96 trees was sprayed in 1937 at the greenflower stage and again at the pink stage with 3 per cent lime sulphur, plus 0.05 per cent. sulphonated lorol. For the petal fall application on May 27th the plot was bisected by a line running east and west, and the spray treatments employed on the two halves were as under :—

Northern Half.

1 gal. lime sulphur.
8 oz. nicotine.
1 gal. oil emulsion (0.67 gal. L. 6 emulsified with 20% sulphite lye).

made up to 100 gal. water.

Southern Half.

1 gal. lime sulphur.
8 oz. nicotine.
½ lb. sulphonated lorol.

made up to 100 gal. water.

No further spray treatments were given and, following the frequent wet periods in June and July, approximately half the crop showed light spotting with scab by the end of August. An opportunity was thus provided for determining whether the two halves of the plot showed differences in scab control.

The whole crop was graded at the time of picking on August 31st, September 1st and 7th, and each fruit was classified as either (1) clean, (2) scabbed but marketable or (3) badly scabbed. Any apple showing more than a single pin spot of scab was excluded from the first category. It was found that the number of apples badly scabbed was negligible, and the results given in Table IV show therefore only total fruits and percentage clean fruits. In this table the figures for each of the east-west rows are assembled, thus giving the results for four blocks of twelve trees for both treatments, each block including one tree on every rootstock.

TABLE IV.

WORCESTER PEARMAIN TRIAL—YIELDS AND PERCENTAGES OF SCAB-FREE FRUIT.

A. Northern Half.			*B. Southern Half.*		
Treated with lime sulphur-oil emulsion.			*Treated with lime sulphur-sulphonated lorol.*		
Block.*	*Total Fruits.*	*Percentage Scab-free.*	*Block*.*	*Total Fruits.*	*Percentage Scab-free.*
1	5323	55.4	5	7601	56.6
2	6131	52.9	6	6952	55.5
3	6043	51.0	7	7916	60.8
4	6354	56.4	8	7108	53.8
Means	5963 ± 223	53.8 ± 1.1		7394 ± 222	55.9 ± 1.3

Difference between mean yields :—1431 ± 315.

Difference between mean percentages scab-free fruit :—2.1 ± 1.7.

* (12 trees).

The results show no significant difference in scab control between the two halves of the plot, but a significant difference in yield in favour of the southern half.

It is therefore shown that the use of petroleum oil emulsion as a supplement to a lime sulphur spray does not diminish its fungicidal value when compared with that of a lime sulphur-sulphonated lorol mixture of the same lime sulphur content. On the question of yield, although there was a significant difference between the southern and northern halves, the lay-out of the experiment in 1937 made it impossible to determine whether this difference was due to position or to treatment. In 1929 and 1930 the two halves were treated alike and in 1929 the mean yield per block of blocks 1—4 (northern half) was 2,186 fruits, and of blocks 5—8, 2,174 fruits. In 1930 the corresponding figures were 1,779 and 1,751 respectively. From 1931 to 1936 the plot was used for a multiplicity of sawfly control experiments and although the northern half each year outyielded the southern this was largely due to the lay-out of the spraying experiments. Thus the evidence available tends to show that the decreased yield of the northern half as compared with the southern half in 1937 was more likely to be due to treatment than to position. Further experiments under more carefully controlled conditions are, however, necessary before this adverse effect of the petroleum oil-lime sulphur mixture can be considered proved.

(iii) Nursery Stock.

The greater portion of a nursery of 3 acres was sprayed with the combined wash mentioned above, using L. 6 grade of oil at 1 per cent. concentration. A second application of the same combination of oil and nicotine was applied at the end of June. Particular care was taken in applying the first wash to ensure adequate wetting of the lower surface of the leaves and the stem. The control of Red Spider was very high, and of Woolly Aphid satisfactory. A negligible amount of foliage injury resulted from the first application and was entirely absent from the second.

(iv) At Borden, Kent.

At Kent Farm Institute a small trial was carried out by Mr. J. B. Duggan with an emulsion L. 6 prepared by Long Ashton. A combined wash of 1 per cent. emulsion (= 0.67 gal. oil) and 0.75 per cent. lime sulphur was applied at petal fall on 27th May to the varieties Bramley's Seedling, Early Victoria, Newton Wonder, Cox's Orange Pippin, Rival, Worcester Pearmain and Lord Derby; no foliage damage of any consequence was noted.

C. Early July Wash = 1st Cover Wash.

Long Ashton.

In view of the satisfactory control of Codling Moth obtained in America with washes of oil emulsion plus lead arsenate or nicotine sulphate, field trials were carried out to determine the phytocidal properties of these washes when applied in early July. This period coincides approximately with the optimum hatch of Codling Moth eggs in this country.

The sulphite lye oil emulsions L. 6, L. 8 and L. 9 were used at 0.67 per cent. concentration of oil with either 3 lb. lead arsenate powder or 20 fluid oz. nicotine sulphate per 100 gal. water, and applied during hot, sunny weather on July 7th and 8th on an 8 acre block of 5-year-old apple trees of Worcester Pearmain, Cox's Orange Pippin, Laxton's Superb, Lord Lamborne, Stirling Castle, Grenadier, Lane's Prince Albert, Bramley's Seedling and Arthur Turner. No foliage injury was observed.

In the previous season, on July 16th, 1936, a block of 4 acres of well-grown trees of the varieties Worcester Pearmain, James Grieve and Bramley's Seedling was sprayed with the emulsion L. 6 and lead arsenate and nicotine sulphate. No foliage or fruit injury was observed. The deposit of lead arsenate was obvious on the apples but it was readily removed by handling during packing. It was interesting to note that it persisted for six weeks despite heavy rainfalls during the period.

BLACK CURRANTS.

Long Ashton.

Previous experiments (3) in which various varieties of black currants were sprayed with a combined wash of 5 per cent. L. 6 oil and 8 per cent. lime sulphur indicated that the addition of the oil emulsion reduced the risk of damage from 8 per cent. lime sulphur. The high concentration of oil was selected for the control of capsid bugs, but in the absence of these pests there would be no object in using more oil than was necessary to aid the spreading of the lime sulphur. A phytocidal test was therefore carried out to determine if a lower concentration of petroleum oil reduced lime sulphur injury. For this purpose a block of 225 bushes of the varieties Baldwin, Black Tony, Westwick Choice, Davisons Eight, Blacksmith and Tinker were divided up so that the following treatments were applied to an approximately equal number of each variety.

1. Unsprayed.
2. Lime sulphur alone.
3. L. 6 plus lime sulphur.
4. Unsprayed.

The oil L. 6 was the same as used in previous trials but at 0.67 per cent. concentration instead of 5 per cent. The oil was emulsified with sulphite lye and the emulsion added to 8 per cent. lime sulphur. The wash was applied on the 19th April, and was followed by slight rain 5 hours later. The flower buds on the racemes were exposed. but were close together at the time of spraying. Observations were made at regular intervals up to the time of picking. Some oil damage was evident on the foliage but it was of negligible amount.

At the time of picking, for the sake of convenience, the total weights of the picks from the different varieties in each treatment were added together giving the following results :—

Crop Weights (Kilos). 56 Bushes per Treatment.

Treatment.	*Total per Treatment.*	*Average Weight per Bush.*
1. Unsprayed	66.6	1.19
2. L.S.	66.6	1.19
3. L.S. and L.6	58.3	1.04
4. Unsprayed	70.6	1.26

The results did not indicate any significant difference between the treatments and it was evident that a trial on a considerably larger number of uniformly grown bushes over several seasons was necessary to provide satisfactory data.

PLUMS.

Further field trials on the joint control of Plum Sawfly and Red Spider clearly showed that the sulphur lye-oil emulsion of L. 6 at 0.67 per cent. oil concentration used in conjunction with *Lonchocarpus* and *Derris* ground roots or their extracts (3) and applied once or twice after petal fall provided a high control of both pests and did not cause any injury to the foliage or fruitlets.

SUMMARY.

(1). Preliminary field trials on apple varieties showed that acid and solvent refined petroleum oils of similar percentage of unsulphonated residue exhibited similar phytocidal properties.

(2). Extensive trials of a combined wash of a Grade G petroleum oil-sulphite lye emulsion, lime sulphur and nicotine applied at petal fall of apples again demonstrated that the wash could be applied to all varieties not sensitive to sulphur without risk of foliage injury.

(3). The addition of the petroleum oil emulsion to a petal-fall lime sulphur wash did not reduce the control of apple scab on the variety Worcester Pearmain. There was an indication that the oil emulsion may have reduced the number of apples picked.

(4). The petroleum oil emulsion applied to black currants at the tight cluster stage and to plums at the petal fall stage caused a negligible amount of injury.

REFERENCES.

(1) Kearns, H. G. H.. Marsh, R. W. and Martin, H. "Combined Washes, Progress Report." *Ann. Rept. Long Ashton Res. Sta.*, pp.109-125, 1934.

(2) Kearns, H. G. H., Marsh, R. W. and Martin, H. "Combined Washes, Progress Report II." *Ibid*, pp. 37-48, 1935.

(3) Kearns, H. G. H., Marsh, R. W. and Martin, H. "Combined Washes, Progress Report III." *Ibid.*, pp. 99-117, 1936.

(4) Fajans, E. and Martin, H. "The Incorporation of Direct with Protective Insecticides and Fungicides.—II." *J. Pomol.* 15, pp. 1-24, 1937.

THE CONTROL OF PLUM SAWFLY.

(Hoplocampa flava L.)

By H. G. H. KEARNS and H. MARTIN.

Introduction.

The Plum Sawfly has been long recognised as a pest of plums, but the infestations in the past have been regarded as sporadic in character, one or more seasons of severe infestations being followed by years of freedom from appreciable losses of crop. Observations made during the past 7 years in the important plum growing districts of the Bristol Province have clearly shown that the distribution of the pest has progressively increased and attacks on some varieties have accounted for very severe losses of crops. Sporadic infestations appear to be associated with certain particular varieties of plums, such as Pershore Yellow Egg, whilst some of the coloured varieties, especially Czar and Victoria, are consistently attacked. During the past few years, an increasing acreage of coloured varieties has come into bearing and it is possible that this fact may account for the increased importance of the pest. As with certain other pests, it may be that the increasing infestations will eventually be checked by some climatic or biological factor, but meanwhile other control measures are desirable on the more profitable varieties consistently attacked. Such control measures are particularly advantageous when they control the other major pest of plums, Red Spider, simultaneously without additional expense. Experiments by Petherbridge and Thomas (5, 6) have shown that derris and quassia washes provide a control of the pest, and Kearns, Marsh and Martin (2) have demonstrated that rotenone-containing materials in combination with suitable spreaders also provide satisfactory results.*

The present paper summarises the experience gained in experiments carried out by the writers on Plum Sawfly control over the seasons 1934-1937, and gives details of the control measures which have been evolved as a result of the work.

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* To be more fully reported in another communication.

Notes on the Life History of the Plum Sawfly.

Damsons and the plum varieties Czar and Victoria are consistently most subject to attack, though other plums, excluding the very early and very late flowering sorts, are also subject to severe but sporadic infestations.

It appears that the sawfly has a marked preference for the varieties Czar and Victoria when they are grown with other sorts, the latter being only attacked under special circumstances such as when Czar and Victoria fail to blossom or their flowering does not coincide with the optimum period of egg laying. It is interesting to note that sporadic attacks occur more frequently in large hillside plantations where the blossom period is prolonged due to differences in shelter, etc.

The sawflies overwinter as larvae within cocoons in the soil and they emerge from early April until about mid-May, the period varying with the climatic conditions. Usually the period of emergence in any season is restricted at the most to three weeks, and is sometimes as little as ten days. The sawflies reach the blossom for egg-laying either by crawling up the tree trunks or more usually by flying. The maximum activity occurs during the late afternoon and evenings of warm, still, sunny days. In dull, windy, or wet weather very little activity takes place and under these circumstances egg-laying may be restricted to a few short intervals of evening sunshine; for example, in 1934, the egg-laying was delayed until nearly full petal fall on Czar plums. One egg is laid per blossom, in the upper portion of the soft green tissue, the "cot," which bears the stamens and surrounds the ovary (which develops into the fruitlet). About 30 eggs are laid by each female. The incubative period of the eggs is about 14 to 18 days, during which time the "cot" becomes detached at its base from the developing fruitlet and gradually dries out, turning brown and becoming brittle. As the fruitlet increases in size, pressure is placed on the drying "cot" which, being an inflexible collar, finally splits longitudinally. The split commences at the lower end (*i.e.* the stalk end of the fruitlet) and extends rapidly or slowly according to the rate of development of the fruitlet.

Often the period when the majority of the "cots" have split for about two-thirds of their lengths coincides with the hatching of the sawfly eggs. The young larva immediately nibbles and consumes a small piece of skin off the fruitlet, a habit of feeding of the greatest importance in so far as control measures are concerned. It rapidly enters the fruitlet and remains inside for about 5 to 7 days. The entrance hole turns black and is readily detected. the larva enters a second plum about a week after hatching from the egg. It becomes fully grown in 4 to 5 weeks, and during this period it enters and damages at least seven plums. During wet weather or in the early morning the second and later instar larvae may be seen wandering over the foliage and seeking fresh plums. They enter fruitlets very rapidly and from the entrance holes wet faeces with a characteristic odour exude. Frequently, a number of nearly full-grown larvae become stuck in the gum of rapidly developing plums, from which they may be seen protruding in a dead, or nearly dead, condition. All attacked plums eventually fall to the ground.

The full-grown larvae find their way to the soil and prepare cocoons in which they remain for one or two seasons.

Methods of Control.

The successful control of Plum Sawfly depends on the application of a suitable stomach poison just before the optimum hatch of the eggs. Of the various insecticides acting as stomach poisons, rotenone-containing materials have provided the most consistently satisfactory results. Only the early first instar larvae are killed by consuming a minute portion of the skin of the fruitlet covered by the insecticide (1). As a rule, the larvae after hatching from the egg enter the upper portion of the fruitlet and it is therefore desirable that a uniform and sufficiently toxic deposit of the insecticide should cover the cuticle of the fruitlet, which particularly at this early stage, is most difficult to wet by means of water soluble wetters. Thus an efficient wetter, such as Sulphonated Lorol at 0.1 per cent., fails to provide a uniform wetting. For this reason, oil emulsions may ensure more satisfactory results because of the superior spreading properties of the oil after the emulsion breaks.

Determination of the Infestation of Blossom.

The control of Plum Sawfly necessitates the application of expensive spray materials and this fact, combined with the sporadic nature of the infestation, particularly on some varieties, renders it desirable to ascertain the chances of infestation. The following method has been used for some years with reasonably satisfactory results.

In the case of the apple sawfly it is comparatively easy to determine the percentage of blossoms infested with eggs and to

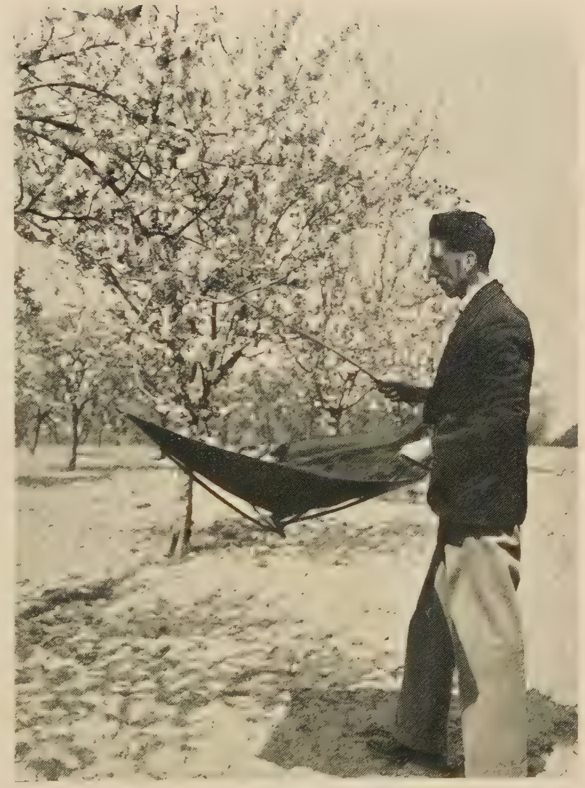

Plate I. Dislodging Plum Sawflies from blossom with the aid of a stick and beating tray.

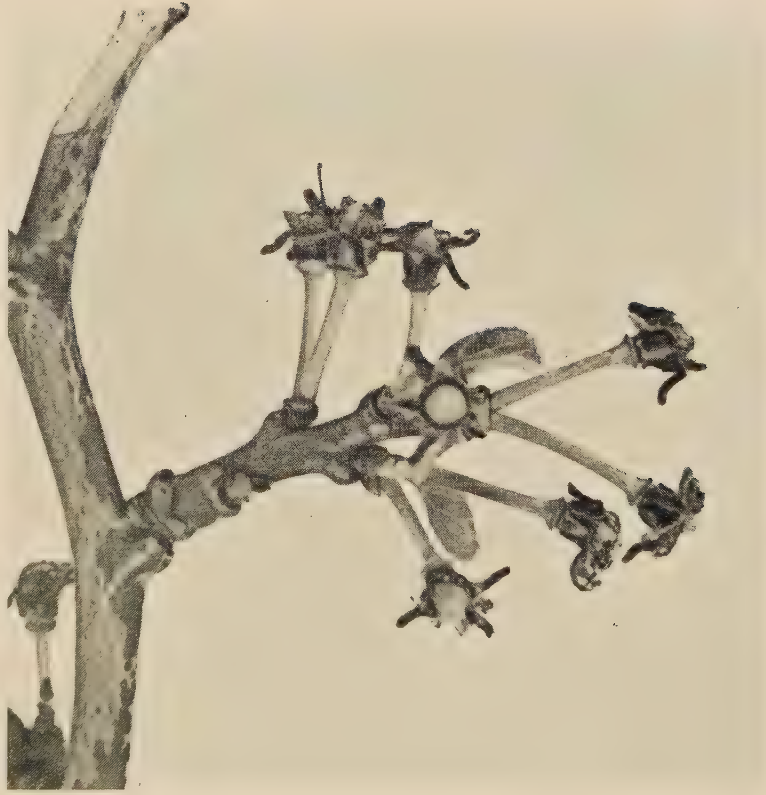

Plate II. The stage of the development of the "cot" selected for the application of the first sawfly wash.

decide from the data if single or double spraying will be necessary. Unfortunately, Plum Sawfly eggs are extremely difficult to detect without suitable laboratory equipment, and therefore a special method of detecting and assessing the probable degree of infestation is required. Such a method, suitable for use by growers, depends on ascertaining whether sawflies are present or absent on the various varieties. An open inverted umbrella, or preferably an entomological beating tray is placed beneath the blossom and the branch jarred with a stick. (Plate I.) The sawflies, if present, fall into the umbrella or tray and may be readily detected after a little practice. Usually, the majority of the sawflies occur in the upper and outer blossoms of the tree and it is therefore desirable to collect samples from as high a point as is convenient. Undue disturbance of the blossom before beating is commenced will cause many of the sawflies to fall to the ground. These observations should be commenced at the date of nearly full blossom of the variety Czar, and are best carried out in the late afternoon and early evening of warm, still days. If the weather is wet, cold or windy, the sawflies remain very sluggish, and none may be seen. Under these latter circumstances the first fine day usually results in a period of intense sawfly activity and the majority of the eggs may be laid within a short period. As a rule a large number of sawflies will not be obtained from a tree on any particular day, but the presence of sawflies, say 6 or more per tree per observation made on two separate days within a period of 10 days, will undoubtedly indicate that an infestation will occur on the particular variety. A consistent absence of sawflies on days favourable for sawfly flight is a fairly safe indication that the attack will be slight or negligible.

Determination of Spray Dates.

The washes described below should be applied just before the hatching of the majority of the eggs. It is impossible under field conditions to ascertain this period by direct observations on the eggs. Generally it may be taken that the application of a wash should be made when the " cots " are split longitudinally for two-thirds of their length (Plate II), and when an occasional fruitlet shows a black entry hole of a recently hatched first-stage larva. If many fruitlets are found with entry holes and the larvae have left them, this indicates that the spraying is too late to be effective.

If a second application is necessary it should be applied one week after the first.

Washes.

Experiments by Long Ashton in 1936 and 1937 have shown that a combined wash of a highly refined petroleum oil emulsion and materials containing rotenone, either the ground root of *Lonchocarpus nicou* or *Derris sp.* or their extracts, provided a high control. It was found that the oil emulsion gave more satisfactory results as a spreader than a water-soluble wetter, particularly when only one application of a wash was given. Not only was a higher control of Plum Sawfly obtained, but a more consistently satisfactory control of Red Spider resulted. The following table summarises the relevant results obtained in so far as the control of the sawfly was concerned.

Material.	*Number of applications of wash.*	*Mean % of infested plums per treatment.*
Extract plus oil emulsion.	1 2	4.23 1.05
Extract plus sulphonated lorol.	1 2	15.45 2.64
Lonchocarpus powder plus oil emulsion.	1 2	16.7 5.2
Control.		43.86

The following wash is recommended :—

1 gall. petroleum oil emulsion (=0.67 gall. oil).
Derris or *Lonchocarpus* ground root or their extracts. (See below).
100 gall. water.

The amount of root or extract to be used is determined by its rotenone content which, in the final wash, should not be less than 0.004 per cent. Thus for a *Lonchocarpus* root of 4 per cent. rotenone, 1 lb. per 100 gall. will suffice. The extracts, with which few growers are yet familiar, are used at an equivalent rate but, in some cases, require previous solution in a suitable solvent. Pending the appearance on the market of extracts in a form convenient for the grower's use, little need be said of these products which, as the above results indicate, may ultimately displace the ground root by reason of their greater efficiency. The oil emulsion must be prepared with an oil suitable for summer use and conforming to the specification Grade G. (4).

As the oil content of proprietary emulsions varies, it is desirable to adjust the concentration at which they are employed to 0.67 gall. actual oil per 100 gallons wash.

If for any reason a water-soluble spreader is preferred, one half-pound of Agral " 2," or Lethalate Wetting Preparation or Sulphonated Lorol per 100 gall. may be substituted for the oil emulsion.

One thorough application of the recommended wash should provide a satisfactory control. If there is any doubt of the correct timing of the application or if the spraying is indifferent, two applications of the wash at an interval of one week are strongly recommended.

It should be noted that in the event of using a water-soluble spreader instead of an oil emulsion, two applications of the wash are generally desirable.

Spraying Technique.

Efficient spraying plays an important part in the control of Plum Sawfly. The determination of the correct spray date and the selection of a suitable wash will be entirely ineffective unless the spraying is carried out carefully and intelligently. The following points must be observed in spraying :—

(1). The open ends of the " cots " must be thoroughly wetted with the wash. It should be noted that an oil emulsion may give an indifferent cover but it is important to remember that, on evaporation of the water, the oil globules coalesce and spread evenly over the surfaces of the fruitlets and leaves.

(2). The upper portions of the tree are frequently the most severely infested, and therefore the wash must reach the top of the tree.

(3). Mist spraying is useless. A drenching application must be given until the wash runs off the tree.

(4). The wash should be projected so that the lower surfaces of the leaves are wetted so that Red Spider may also be controlled.

Summary.

1. A summary of investigations on the control of Plum Sawfly is given in so far as they are of practical importance.

2. A method of determining the infestation of plum blossom is described.

3. A combined wash of highly refined petroleum oil emulsion and a rotenone containing insecticide (*Derris* or *Lonchocarpus* root or extracts) provided a high control of the pest.

4. The oil emulsion was more efficient as a spreader than a water soluble wetter.

5. An extract of *Lonchocarpus nicou* gave a more potent combined wash than the powdered root.

REFERENCES.

(1) KEARNS, H. G. H. "The Control of Plum Sawfly. (*Hoplocampa flava* L.)" *The Worcestershire County Council Agri. Quart. Chronicle*, 5, 3, pp.137–145. 1937.

(2) KEARNS, H. G. H., MARSH, R. W. and MARTIN, H. "Combined Washes, Progress Report—III." *Ann. Rep. Long Ashton Res. Stat.*, pp. 99–117. 1936.

(3) KEARNS, H. G. H. and MARTIN, H. "The Use of Sulphite Lye as an Emulsifier." *Ann. Rep. Long Ashton Res. Stat.*, pp.118–123. 1936.

(4) MARTIN, H. "The Standardisation of Petroleum and Tar Oils and Preparations as Insecticides." *Ann. App. Biol.* XXII, 2, pp. 334–414, 1935.

(5) PETHERBRIDGE, F. R. and THOMAS, I. "The Control of Plum Sawfly (with a note on Thrips damage)." *Journ. Min. Agric.*, XLII, II, pp. 1108–1118. 1936.

(6) PETHERBRIDGE, F. R. and THOMAS, I. "Spraying for Plum Sawfly with notes on Red Spider and Thrips." *Journ. Min. Agric.*, XLIV, 9, pp. 858–865, 1937.

THE ORIGIN OF INFESTATION BY THE OAT STRAIN OF THE EELWORM *ANGUILLULINA DIPSACI* (KÜHN).

By C. L. WALTON.

Introduction.

Anguillulina dipsaci (Kühn) is only too well known as the cause of serious losses in oat crops through the diseased conditions commonly known as "tulip root," "segging," etc., the symptoms being stunting, deformities and decay.

Owing to difficulties of treatment on a field scale, control is usually attempted by omitting oats from the rotation for a number of years, and Robertson (1) as the result of experimental work states that this period should extend at least to four years.

Numbers of complaints as to losses due to this pest have been received at Long Ashton, and a number of these have been investigated and as much information as possible gathered regarding the histories of the fields concerned, sources of seed, or other sources of origin of the infestations.

In a majority of instances there had been cropping with oats, within the four year period, but some severe infestations had occurred at the end of four years free from oats, and in one instance, after a lapse of eight years.

Unfortunately, farmers are apt to overlook a mild infestation and to sow oats again within two years, with disastrous results.

It was felt that further investigations were needed.

Possible Sources of Origin of Infestations.

(1). *The Soil.* In a majority of the cases investigated it was found that, following a previous attack, oats had been sown within the four year period and that serious losses had resulted.

(2). *The Seed.* Hodson (2) recorded the occurrence of this disease at a number of different centres, the seed having been obtained from a common source, which was a diseased crop, but he states in a letter to the writer dated 13/11/35, " my opinion is that while the eelworm *can be* and *is* present in seed, it is only in small numbers, and would be unlikely to cause a complete failure of the crop. If oats were grown again on the same land immediately I should anticipate a serious attack. On the other hand if seed from a badly infested field were used, a rather unlikely contingency, one might anticipate a serious failure." Robertson (1) investigated attacks on oats and beans in Scotland, and states that eelworms can be found in the grain from an infested crop. He concludes that: " No farmer should, therefore, sow or sell for seed, oats harvested from an infested field, and that larvae will survive amongst dry straw for a period of six years."

Goodey (3) states: " One of the most difficult things to account for in both diseases (tulip root of oats and stem-sickness of clover) is their sudden appearance in fields where the preceding crops in a rotation are non-susceptible ones, or, if susceptible, have shown no obvious evidence of eelworm infestations. Two possible explanations suggest themselves (*a*) that the parasite is seed borne or (*b*) that there may be a light natural infestation of weeds from which the organism passes over the crop." He further discusses this side of the problem in some detail.

(3). *Other Crops.* Field beans and clovers are known hosts of this eelworm, but no definite evidence of their occurrence in connection with infestations of oats was obtained during the writer's enquiries.

(4). *Weeds.* These, as quoted above, were open to strong suspicion and have been examined with results given later. During the progress of the work Johnson (4) has recorded *Galium Aparine* and *Stellaria media* as host plants.

Experimental Work, 1936-37.

1936.

Seed from Infested Crops as a Source of Infestation.

A. Plot Trials.

In order to test this in a practical manner a plot was sown at Long Ashton, in 1936, on land not previously known to have carried an oat crop, with seed harvested during 1934 and 1935 from heavily infested crops. The plot was 24 yards square and was sown on March 17th, 1936, in strips, each 12 yards long and about 6 inches wide.

Unit 1. 10,000 seeds of " Whitehorse " oat from near Taunton, Somerset.
,, 2. 10,000 seeds of S.82 (1935 crop) from near Bridgwater, Somerset.
,, 3. 10,000 seeds of S.82 (1934 crop) as sown near Bridgwater, Somerset.
,, 4. 10,000 seeds of " Superb " (1934 crop) from near Hereford.
,, 5. 10,000 seeds of " Whitehorse" from near Taunton, Somerset.

The germination rate and history of all these were known.

B. *Pot Trials with Sterilised Soil.*

In addition, the following series of these oats were sown at Long Ashton in sterilised soil contained in 14in. pots, and kept under a wire cage.

Series 1.	8 pots, each containing 200 seeds of Superb, from near Hereford	1,600
,, 2.	8 pots, each containing 150 seeds of S.82, from near Bridgwater (1935)	1,200
,, 3 ,, 4	16 pots, each containing 200 seeds of " Whitehorse," from near Taunton	3,200
	Total	6,000

In these series, therefore, there were 56,000 seeds drawn from heavily infested crops, except that the sample of S.82 of 1934 was seed as received from Cambridge, and as sown near Bridgwater.

C. *Pot Trials with Infested Soil.*

As a control to the above listed series, soil was taken from the infested land near Bridgwater, after shallow ploughing, on 8/11/35. Eight 12-inch pots were half filled with potting soil, and then filled up with soil (a heavy loam) from the Bridgwater field.

1. 100 seeds of " Marvellous " Oats, of which the history was known and believed to be entirely free from eelworm, were sown in each of four pots on 13/11/35.
2. 100 seeds, as above, were sown in the remaining four pots, 3/3/36.

There was thus a total of 800 seeds in the Series. All pots were kept in an unheated glasshouse.

Previous History of the Oat Samples.

It is thought that a brief account of the history of some of these oats may be of interest.

I. *Whitehorse* was obtained direct from the grower, and the infestation was seen personally. It was, as usual, patchy, but severe. Three fields had been sown, 11 acres in all; two fields adjoined and the third was near by. The two adjoining fields were very heavily infested. The land is hilly, and weeds were numerous.

Rotation.

1931	Roots.
1932	Oats.
1933	Barley.
1934	Wheat.
1935	Oats (infested).

The sample taken for trial was drawn from several separate, sacks, harvested from fields 1 and 2. Thanks to the kindness of the seed merchant, the origin of this seed was traced. Mr. G. E. Furze, Crop Recorder at Cannington Farm Institute, Somerset, kindly visited the farm concerned and found no history of infestation. Seed from this source also grew normally on several other farms in 1935. This sample was therefore presumed to be clean when sown.

II. *S.*82. This is a White Winter Oat, bred at the Welsh Plant Breeding Station, Aberystwyth, handed over to the N.I.A.B. for trial in 1932, and grown by them during 1933 and 1934. It was received by Mr. G. E. Furze at Cannington in the autumn of 1934 and sown on a selected farm on October 24th under excellent conditions.

Rotation.

1922	Oats—" A complete failure " cause not known. History uncertain until 1927, but no oats were grown.
1927	Oats—a poor crop. Very wet year and heavy crop of clover.
1928	Ley.
1929	Wheat.
1930	Kale—fed off.
1931	Barley.
1932	Ley.
1933	Wheat.
1934	Beans—not a good crop.
1935	Oats—heavily infested.

It is seen that the history for oats is poor, and that beans in 1934 were damaged. Seed was obtained for the trial from the 1935 crop.

III. *Superb.* The seed from which this crop was grown came from near Ross, Herefordshire, in 1933, and on account of excellence was purchased by a seed-merchant and sold to various holdings and, as far as could be ascertained, gave excellent results except on the one farm near Hereford, where the infestation was so severe that the crop was " fed off," and in consequence no seed was available. Sufficient of the seed as sown was, however, obtained, and this was used in the trials. Oats had been grown in this field in 1929 (or 1930) and again in 1934 when the crop was described as " light " (attributed to drought). There was a history of " clover sickness " which was proved, however, to be due to attacks of *Sclerotina*. Following the 1935 crop failure the field was seeded down, and the resulting clover remained free from eelworm infestations.

Here, we have close cropping with oats, and a failure following a " light " crop.

Results of 1936 Trials.

Plot and Pot Trials (*A. and B*).

Throughout the growing season all plants were examined at intervals of a month, and suspected plants were subjected to microscopic search. Nevertheless no case of infestation was detected and an excellent crop resulted.

C. *Pot Trials with Infested Soil.*

(*a*) Oats sown 13/11/35.

All seeds germinated well and reached a height of 6 to 12 inches before symptoms of infestation commenced in the week March 15–21st, 1936.

(*b*) Oats sown 3/3/36.

First symptoms of attack were noted 13/5/36 when plants averaged 12 inches in height—ten weeks from date of sowing.

On ripening, the oats in both the strip plots and pot trials were cut down and removed, and after the rows had been demarcated, the soil, together with the stubble was carefully inverted by hand digging.

1937.

In order to test the possibility of a small eelworm population being present both plots and pots were resown with " Marvellous " oats obtained by Mr. G. E. Furze from Cambridge and believed to be entirely free from infestation. These were sown as follows : –

(*a*) *Strip Plots*, 6/4/37.

Using 2,000 seeds per plot, giving a total of 10,000 seeds.

These were sown upon the line of the previous years growth, to ensure proximity to any eelworms that might be present. The reduction in the number of seeds was primarily for the purpose of concentrating any such attack to the point of producing symptoms, and partially to facilitate examination. The date of sowing was late on account of the abnormally wet condition of the soil.

(*b*) *Pots.*

The series of 32, 14-inch pots was likewise resown (with the same batch of oats) on 5/4/37, using 50 seeds per pot—a total of 1,600 seeds.

Results of 1937 Trials.

All plants were again carefully examined at intervals throughout the season, but not a single case of infestation could be detected. There was a patchy infestation of Frit Fly (*Oscinella frit*) on the plots which caused much distortion and stunting, necessitating prolonged and careful examinations, both macro and microscopic.

Weeds as Host Plants of *Anguillulina dipsaci.*

1936.

Weeds growing amongst infested crops were observed throughout all crop examinations, and any plant showing deformity or abnormality of foliage was examined microscopically.

At the Bridgwater centre some plants of the lesser bindweed (*Convolvulus arvensis L.*), which showed dwarfing and distortion, yielded a few specimens of *A. dipsaci*, but no other definite evidence was obtained.

Johnson states, in a paper which appeared in December 1934 (4), that, " the occurrence of the eelworm has been noted on two weeds, namely cleavers (*Galium Aparine L.*) and chickweed (*Stellaria media* Cyrill)." " The writer first obtained infested specimens of both weeds in spring 1936 " . . . . . " It was difficult to recognise any definite symptoms in infested chickweed, but all infested cleavers plants showed yellowing of the lower leaves without any signs of swelling or distortion of stem or leaves." The writer adds : " These findings are highly suggestive that the two weeds may be partly, if not wholly responsible for the persistence of the oat strain of *A. dipsaci.*

Following up Johnson's observations, infested plants of *G. Aparine* were obtained from the field near Bridgwater. At the date of examination, 22/4/37, the plants were well past the seedling stage, averaging from 1½ to 3 inches in length. The lower leaves of many were discoloured and yielded *A. dipsaci.*

None of the other weeds present proved to be host plants, and the only plant of chickweed found was healthy.

At the Taunton centre, where barley had been drilled a few days before, the field was practically clear of weeds on 22/4/37, but two seedlings both in the cotyledon stage (? *Veronica sp.*) showed yellow areas, and one of them yielded six specimens of the eelworm. On 2/6/37 weeds were relatively abundant and of these seedlings, *Veronica agrestis*, which was common, showed in a number of instances yellow areas which yielded eelworms. Young plants of Charlock (*Brassica sinapis* Visiani) which were in the 4 and 6 leaved stages also proved to be infested. Goodey (5) records *Veronica serpyllifolia L* and *Sinapis arvensis L* (Charlock) as host plants.

Neither cleavers, nor chickweed appeared on this field.

Since Johnson (4) states that he is carrying out work on this subject, no further steps were taken.

Discussion.

The experiments described above support the view that the chances of an infestation of *A. dipsaci* arising from the use of seed from an infested source cannot be great, and that weeds are the usual source of and reservoir for this pest on agricultural land, and would readily account for the occurrence of serious infestations even when oats have been omitted from the rotation for a considerable period. It would appear, unfortunately, that a number of the most abundant weeds of arable crops can act as host plants. It has been shown by Hodson (6) that Cocksfoot grass, *Dactylis glomerata L*, is particularly susceptible to attack by the oat strain of the eelworm, and Goodey (5) lists a number of other agricultural grasses as host plants. It is, therefore, evident that the omission of oats from the crop rotation of infested fields for a period is not alone sufficient, and that to lay down the land to grass for a similar period may not suffice to starve out the parasite. Moreover, the adoption of the most drastic measures for clean cultivation are absolutely essential in order to keep the eelworm population below the danger level.

Conclusions.

1. A series of plot and pot trials, using seed obtained from oat crops heavily infested with the eelworm *Anguillulina dipsaci*, failed to show any infestation from that source.

2. It was confirmed that several species of weeds common to agricultural land act as host plants.

3. From the data at present available it would seem that infestations of oat crops which occur, even after the absence of that crop for more than six years, are in all probability attributable to weeds rather than to infested seed. Clean cultivation is thus shown to be of great importance.

Acknowledgments.

The writer wishes to thank Mr. G. E. Furze, of Cannington Farm Institute, for assistance and information; also farmers and seed merchants for facilities for observation, for samples of seed oats, and for information regarding their origins. Also to the Official Seed Testing Station at Cambridge for reports on the percentage germination of some of the oats used in the trials.

REFERENCES.

(1) Robertson, D. *Scottish Journ. Agric.* XVIII, pp. 47–52. Jan. 1935.

(2) Hodson, W. E. H. *Estates Magazine* XXXIII, pp. 198–201. 1933.

(3) Goodey, T. *Ann. Appl. Biol.* XXIII (2), pp. 203–230. 1936.

(4) Johnson, L. R. *Jnl. Helminthology* XIV (4), pp. 233–235. Dec. 1936.

(5) Goodey T. "Plant Parasitic Nematodes," *London*, pp. 52–65. 1933.

(6) Hodson, W. E. H. *Ann. Appl. Biol.* XVIII, pp. 88–99. Feb. 1931.

TARSONEMUS SPIRIFEX MARCH, AS AN OAT PEST.

By C. L. WALTON.

Mites of the family Tarsonemidae, are already recognised as the cause of loss amongst economic plants. *Tarsonemus fragariae* Zimm is only too well known as a most serious pest of strawberries, and under glasshouse conditions *T. pallidus* Banks is called the Begonia or Cyclamen Mite, whilst *T. latus* Banks is known as the Broad Mite and also attacks fuchsias. *T. tepidariorum* Warburton is the cause of serious symptoms in the fern *Asplenium bulbiferum* and *T. approximatus* Banks var. *narcissi* is responsible for the loss of narcissus bulbs especially when forced. Other species responsible for crop injuries are not yet known to occur in this country.

This note is written to draw attention to yet another species, *T. spirifex* March, which is capable of causing a serious reduction in oat crops grown under farm conditions.

The Tarsonemid mites are of very small size, being less than 1/100th of an inch in length ; the body is elongate and colourless or ivory white or light brown, and the males and females are very different in appearance. In both sexes the first and second pairs of legs are directed forward and are widely separated from the third and fourth pairs which are directed backwards ; in the female the last pair are greatly modified and terminate in a forked bristle, whilst in the male they are strong clasping organs. The larval stages are similar but possess only six legs. The ova are comparatively large.

The mites pierce the plant tissues with stylet-like mouth parts and suck the sap : discolouration, distortion, galling and reduction in yield are the result.

T. spirifex was originally described from oats by Marchal (1), who noted the characteristic spirally twisted rachis and states that the ears usually remain within the sheath in infested plants.

A short description of this pest is also given by Balachowsky and Mesnil (3), who state that this pest also occurs in Russia, Germany, Denmark, Scandinavia and Holland. Rye and certain grasses are also stated to serve as hosts. These writers also quote several continential authors in support of the above statement and mention the occurrence there of other mites which infest Gramineæ.

T. spirifex in the Bristol Province.

G. H. Corbett (2) recorded this mite as infesting oats on the farm of the Royal Agricultural College, Cirencester, in July 1912. He states that the crop was uneven and that some oat stems had become red in colour, which discolouration was greater where mites were most numerous. Eggs were present in large numbers. The mites were identified by Mr. C. Warburton. Corbett records both male and female mites.

In July, 1937, a sample of " Star " oats, grown at Winterbourne Stoke, was received from Mr. H. W. Tomlinson, Assistant Agricultural Organiser for South Wilts, twenty acres being affected.

The field showed uneven growth and the plants a most curious reddening of the stems. Many of the stems were distinctly dwarfed and there was a marked twisting of the rachis of the panicle and a certain amount of " blindness." Examination disclosed the presence of very considerable numbers of mites (and their larvae and ova), within the leaf sheaths and the glumes. Two days later oats similarly affected were received from Cannington Farm Institute, Somerset, but in this case the infestation was less severe and the symptoms less marked.

Subsequently a further consignment from Wiltshire strengthened the opinion that the discolouration, stunting and other symptoms were distinctly correlated with the degree of infestation.

The identification was confirmed by Mr. C. T. Gimingham, of the Plant Pathological Laboratory, Ministry of Agriculture and Fisheries, who stated that their staff were aware of several cases of infestation.

No control measures are suggested since so little is known regarding the factors leading up to an infestation, *e.g.* the presence of wild host plants, etc.

The writer would welcome the opportunity to make further investigations.

Summary and Conclusions.

1. The Mite *Tarsonemus spirifex* March is at times the cause of serious loss to farm grown oat crops in this country, and such cases have occurred in Gloucestershire, Wiltshire and Somerset in 1912 and 1937.

2. The symptoms of attack include the presence of the mites within the leaf sheaths and glumes, a characteristic contortion of the rachis, stunting of the entire plant in severe cases and the presence of a reddish discolouration varying with the degree of infestation.

REFERENCES.

(1) Marchal, P. *Bulletin de la Societé Entomologique de France.* No. 4., p. 98. 1902.

(2) Corbett, G. H. "Mites of the Genus *Tarsonemus* causing disease on *Gramineæ.*" *Ann. Sci. Bull.*, 4–5. *Roy. Agric. Coll., Cirencester,* pp. 93–95, 2 figs. 1914.

(3) Balachowsky, A. et Mesnil, L. "Les Insectes Nuisibles aux Plantes Cultivées." Vol. 1, pp. 1136–37, Paris. 1935.

PROGRESS REPORT ON VEGETABLE DISEASES.—IX.

By L. OGILVIE and C. J. HICKMAN.

The following report is a summary of the work on Vegetable Diseases in the Bristol Province carried out during the season 1936-1937 and is a continuation of those published previously.

ASPARAGUS DISEASES.

Asparagus Rust.

It will be remembered that asparagus rust was recorded in England, for the first time in recent years, in 1933, when it was found to be widespread in the Eastern Counties and in one isolated spot at Badsey, near Evesham (5). The affected bower in the latter case was destroyed and the rust was not seen in the Evesham area during the years 1934 to 1936.

Unfortunately it has again become conspicuous. A very slight infestation was discovered in the Offenham district on October 2nd. 1937, patches of teleuto-sori occurring on a few widely separated plants throughout a field. Subsequent surveys revealed its presence in practically every field in the Vale of Evesham, but only in very slight amount. In one planting however, near Badsey, in a low-lying situation, the bower was severely affected and dying off prematurely.

As indicated in our 1933 Report, it is thought that the rust has been present in England in non-epidemic form for many years and that epidemics are liable to occur in hot and dry summers with heavy dews, as in the months of August and September of 1937.

Every effort was made to advertise the necessity of early cutting and burning of the bower in the affected area. An article was published in the Vale of Evesham Growers' Assn. Year Book for 1937-1938 giving detailed information of the history of the disease in England and elsewhere, the biology of the fungus and suggested control measures. The most important means of control appear to be early and thorough cutting and burning of the bower and thorough cutting of buds in spring.

The infection of "maiden" plants, however, which we have observed in the Evesham district, provides a source of infection which it seems impossible to prevent unless seedling beds are well isolated from the main plantings. This is one of the chief control measures now in force in Germany.

Rust is most likely to be serious where there is little free circulation of air. Plantings should therefore be located in fairly exposed situations and should not be bounded by hedges or trees. It is best to have the rows running in the direction of the prevailing wind.

DWARF BEAN DISEASES.

Field Trials.

In the summer of 1937 four field trials of dwarf beans were laid down to obtain data on classification, earliness, market value and response to diseases. We have to thank seedsmen for supplying samples of seeds.

In the main trial, at Long Ashton, 67 varieties were included, while in the other three, at the Worcestershire County Horticultural Experiment Station, Perdiswell, at Avoncroft Agricultural College, Stoke Prior, and in the fields of a grower at Bengeworth, Evesham, 41 varieties were included.

The most satisfactory results were obtained from the Long Ashton and Evesham trials, the others lacking uniformity owing to soil or other conditions.

It is not proposed to present here in detail the characteristics of the varieties or counts of disease in the various trials. It has been found possible to summarise the results in Table I so as to present the characteristics of the various groups of dwarf beans and their response to diseases. The groups are those suggested by Hoare, in the Ministry of Agriculture Bulletin on "Beans" (No. 87), but it has been found advisable to add several sub-groups to his classification.

The following notes are explanatory of Table I. The varieties mentioned are among those included in the trials.

1. *Seed Colour.*

The groups under consideration can be distinguished readily on the basis of seed colour alone.

Group 1 is a well defined group with black seeds, comprising several valuable varieties. The trials included the varieties Black Prince, Black Wonder, Treasure and Waite's Extra Early Prolific Negro.

It has been found advisable to divide Hoare's group 2, comprising varieties with dun-coloured seeds, into three sub-groups based on seed colour and not on foliage colour, as suggested by Hoare.

The colour of the seeds in our group 2A is medium to light brown, resembling that of group 4, but distinguished from it by a pinkish tinge and the absence of the characteristic sheen of group 4. This sub-group includes Bounteous, Bountiful (Finney), Evergreen, Perpetual, Plentiful, and Wonderful.

Group 2B has chamois-coloured seeds and comprises African Wonder, Bountiful (Webb), Victory (Afrikander), Masterpiece.

Group 2C has dark brown seeds and includes Incomparable, Premier and Zenith.

Group 3 is a very distinct group, comprising early varieties having seeds speckled with various shades of brown, red, purple and buff. It includes the following :—Early Prolific, Early Warwick, Fifty Days, Langport Wonder, Long Tom, The Prince and Williams' Earliest of All.

Group 4 has seeds of a glistening amber brown and includes Harbinger, Ne Plus Ultra and Sunrise.

Groups 5 *and* 6 of Hoare, comprising Flageolet and forcing types, were not included in the trials.

Group 7 is very distinct, including popular varieties with dark purple seeds, such as Canadian Express, Canadian Wonder, Lightning and Peerless.

Group 8 has seeds half brown and half white or white mottled with brown, and includes Abundant, Market Favourite, Satisfaction, The Wonder and The Sultan.

Group 9 is divided into two sub-groups. 9A has seeds half black and half white, or white seeds mottled with black, and includes Foremost, Magpie and Superlative. 9B has characteristic large white or cream seeds with brown to black markings round the hilum, and includes Early Giant, Goliath, Leicester Wonder, Magnum Bonum and Unrivalled.

Group 10 has pure white seeds, and includes Abundance, Emperor William, Supreme and White Queen.

Group 11 comprises stringless canning varieties, having black seeds with orange markings, and includes Full Measure, Keeney's Stringless Refugee and Stringless Greenpod.

Group 14, of Hoare, comprises treble-purpose beans, such as Princess and First of All White Forcing, with white seeds.

It should be noted here that the seed colour of dwarf beans darkens with age. In the case of the varieties under trial the colour of fresh seeds and seeds approximately six months old were matched with Ridgway's Colour Standards.

2. *Colour of Foliage.*

Varieties of dwarf beans differ greatly in the colour of their foliage, some having dark green leaves, others light green and others again leaves intermediate in colour or " medium green."

It was found that the foliage colour was best estimated on plants growing in a non-calcareous soil, since all varieties suffer from lime-induced chlorosis in limestone soils.

As indicated in Table I foliage colour is usually not uniform throughout the groups, except in groups 1 and 11 in which it is " medium green "and in groups 8, 9A and 10 in which it is dark green.

3. *Flower Colour.*

Most of the varieties have lilac or mauve flowers, and according to our observations the intensity of the tint may vary within the groups. No group, however, contains both lilac flowered and white flowered varieties. Groups 8, 9A, 9B and 10, all of which have white or partly white seeds, have also white flowers.

4. *Earliness.*

Groups 1, 8, 9A and 9B mainly comprise early varieties, but the other groups include both early and late sorts.

TABLE I.

Dwarf Bean Trials, 1937. Summarised Data.

Group.	Seed Colour.	Foliage Colour.	Flower Colour.	Earliness.	Shape of Pods.	% Halo Blight			% Mosaic			% Anthracnose.
						On Pods. L. A.	On Plants. L. A.	Ev.	On Pods. L. A.	On Plants. L. A.	Ev.	L. A.
1.	Black.	Medium green.	Lilac.	Early.	Well-shaped.	13	16	12	32	10	10	4
2 A.	Medium to light brown with pinkish tinge.	Pale to dark green.	Light lilac.	Early to late.	Relatively short.	8	20	7	21	10	10	11
B.	Chamois.	Pale to medium green.	Light to very light lilac.	Early to late.	Well-shaped to irregular.	9	39	31	49	9	12	8
C.	Dark Brown.	Medium to dark green.	Light to very light lilac.	Early to late.	Short : irregular or well-shaped.	3	12	4	39	3	11	3
3.	Speckled with various shades of brown, red, purple and buff.	Pale to dark green.	Usually very light lilac.	Early to late.	Various.	11	24	30	34	3	27	9
4.	Glistening amber brown.	Mostly dark green.	Very light lilac.	Usually early.	Usually well-shaped.	1	12	3	24	3	20	4
7.	Dark purple.	Pale to medium green.	Very light lilac.	Early to late.	Well-shaped.	5	49	54	25	6	27	3
8.	Dark dun and white.	Dark green.	White.	Early.	Well-shaped.	4	13	12	31	2	2	20
9 A.	Black and white.	Dark green.	White.	Early.	Well-shaped.	1	5	1	30	3	3	6
B.	White ; brown to black markings round hilum	Medium to dark green.	White.	Early.	Various.	2	31	22	36	4	5	1
10.	White.	Dark green.	White.	?Late.	Small and irregular.	0	12	21	40	30	6	3
11.	Black with orange markings.	Medium green.	Light to deep purple.	—	Small.	–	4	—	—	11	–	7

5. *Shape of Pods.*

Measurements were made of the pods of all the varieties, and in Table I an indication is given of the shapes of the pods in the various groups. "Well shaped" pods are relatively straight, at least 7 inches long by 0.5 inches broad, and free from objectionable purplish markings.

6. *Amount of Disease on the Plants.*

A. Halo Blight. The percentage of halo blight, caused by *Bacterium Medicaginis* var. *phaseolicola*, occurring on the pods in the Long Ashton trial, was estimated on July 29th and August 10th, while the amount of halo blight on the plants was estimated on July 20th and August 18th. The amount of halo blight on the plants in the Evesham trial was estimated on July 28th.

It will be seen from the column in Table I indicating the average percentage of halo blight on the pods in the various groups in the Long Ashton trial on August 10th that this percentage is in no case very large and is not closely correlated with the number of plants infected with halo blight. This finding agrees with results obtained in trials in other countries (6), where it has been found that resistance of the plants to the disease does not necessarily mean freedom of the pods from bacterial spotting. The chief damage done by the disease, except possibly in very wet years, is in checking the plants and reducing the yield.

The two columns following indicate the average percentage infection with halo blight of the various groups at Long Ashton and Evesham respectively. It will be seen that these figures approximate fairly closely in most cases, showing that the group is either resistant or susceptible. When the corresponding figures for individual varieties are considered as in Table 2, it is apparent that some varieties are noticeably more resistant than the other members of the group to which they belong.

It will be seen from Table 2 that groups 2B, 3 (except for one variety) and 7 are clearly susceptible, while 2C, 9A, 10, 11 and possibly 1 and 8 are mainly resistant.

Groups 3 and 7 include the most popular market varieties. Practically all these have been shown to be highly susceptible, but The Prince in group 3, a valuable variety on account of its earliness, has been shown to be resistant, thus confirming trials carried out in South Africa (7). Peerless in group 7 also appears to be resistant.

TABLE II.

Relative Resistance of Dwarf Bean Varieties to Halo Blight in Two Trials, 1937.

Group.	*Per cent. Infection in Group.* *L. A.*	*Ev.*	*Per cent. Infection of Resistant Varieties.*	*L. A.*	*Ev.*	*Susceptible Varieties.*
1.	16	12	Treasure ..	2	3	——
			Black Prince ..	16	17	
			Black Wonder ..	20	12	
			Waite's Early Prolific Negro ..	10	13	
2 A.	20	7	Perpetual ..	5	4	Bountiful, Plentiful, Wonderful.
			Bounteous ..	5	9	
			Evergreen ..	6	3	
2 B.	39	31	——			African Wonder, Bountiful, Masterpiece, Victory.
2 C.	12	4	Incomparable ..	4	4	Zenith.
			Premier ..	10		
3.	24	30	The Prince (A) ..	5		Early Prolific, Early Warwick, Fifty Days, Langport Wonder, Long Tom, Williams' Earliest of All.
			do. (B) ..	5	16	
			do. (C) ..	14	20	
4.	12	3	Ne Plus Ultra ..	2	3	Harbinger, Sunrise.
6.	13		——			——
7.	49	54	Peerless ..	1		Canadian Wonder, Selected Canadian Wonder, Canadian Express, Selected Lightning.
8.	13	12	Abundant ..	7	10	The Sultan, The Wonder, Satisfaction.
			Market Favourite	6	0	
9 A.	5	1	Foremost ..	5	1	
			Superlative ..	6	1	——
			Magpie ..	0		
9 B.	31	22	Unrivalled ..	11		Early Giant, Goliath, Leicester Wonder, Magnum Bonum.
10.	12	21	White Queen ..	8		
			Abundance ..	7	3	Supreme.
			Emperor William	0		
11.	4		Full Measure ..	0		——
			Keeney's Stringless Refugee	3		
14.	0		Princess (Sugar Pearl) ..	0		——

Group 11, which comprises the canning beans, is well known for resistant varieties, and the two members of this group included in our trials were found to be resistant,

To summarise, it has been shown that the susceptibility or otherwise of a variety may often be estimated on the basis of seed colour alone. The comparative resistance of Abundant, Black Prince, Black Wonder, Ne Plus Ultra, Superlative and Unrivalled, indicated in our 1931 and 1932 trials (3, 4) and in trials elsewhere (6, 7) has been confirmed, while several other varieties have been added to the resistant list.

B. Mosaic. It will be seen from Table I that at Long Ashton the percentage mosaic infection of the pods was high. Since the symptoms are usually severe, considerable depreciation of the samples may result.

It was not expected that any very considerable differences in mosaic infection would be apparent in the trials and no great differences did in fact result. It was noticeable, however, that varieties with dark green foliage were less liable to mosaic on the leaves. This is seen in groups 8, 9A and 9B and in individual varieties, such as Bounteous, Perpetual, Fifty Days, Sunrise, Selected Lightning and Early Giant.

In the case of one variety, William's Earliest of All, the seed was heavily infected with mosaic. This resulted in 44% infection in the Long Ashton trial on July 20th and 94% infection on August 18th, showing that spread took place in the course of the summer.

C. Anthracnose. Anthracnose (*Colletotrichum Lindemuthianum*) appeared late in the season in the Long Ashton trial and no high percentage of infection was observed in any variety. Infection appeared to spread across two rows, so that a heavily infected variety influenced those on either side.

The following varieties were free from infection :—

> Hundred for One, Selected Canadian Wonder (Sutton), Foremost, Magpie, Leicester Wonder, Abundance, Emperor William, Princess (Sugar Pearl).

Of these Princess and Hundred for One also remained entirely free from anthracnose infection in 1936.

Mosaic of Dwarf Beans.

Mosaic of dwarf beans, which was first recorded from England by Grainger (1), was referred to briefly in our 1936 Report. It will be seen from Table I that in the Long Ashton trial it occurred on the pods to an extent of over 30%. The disease was also found in the other trials to an almost equal extent.

The mosaic disease which occurs on these beans in this area appears to be mainly " Common Bean Mosaic " caused by Phaseolus Virus 1. The symptoms are severe mottling and blistering of the leaves accompanied by downward curling of the edges. The plants and leaves may also be reduced in size. The pods are distorted and roughened and may be covered with so-called " hydrotic spots," small warts or pimples somewhat suggestive of halo blight infection.

In the trials in question counts of mosaic on the plants showed that it increased considerably throughout the season. The aphis most commonly occurring on dwarf beans is *Aphis rumicis*.

DISEASES OF RUNNER BEANS.

Sclerotinia Disease.

In our 1937 Report a Sclerotinia disease was mentioned which affected runner beans in the Offenham district, near Evesham. The fungus has been identified as *Sclerotinia Sclerotorium* and has been found in greenhouse experiments to be pathogenic to runner beans, dwarf beans and lettuces.

LETTUCE DISEASES.

Field Trials.

Trials of Winter Lettuces were laid down at the Worcs. County Expt. Stn., Perdiswell, in 1935-36 and 1936-37. These have been described fully in the Worcs. Quarterly Agr. Chronicle (2), where details of the trials are given. The general conclusions arising from the trials are as follows.

Both trials show that very considerable loss may ensue from Botrytis attack. Thus in Trial 1 the variety with the highest survival rate suffered over a quarter loss, while the average survival rate of the 41 varieties was 41%.

The great differences in weather conditions during different winters render it unwise to generalize regarding winter hardiness or Botrytis resistance, since the latter appears to be connected with winter hardiness.

Again, varieties sold under the same name by different seedsmen, or even different lots of the same seed from the same seedsman, may differ in constitution. This may explain the variation which appears in the results from year to year.

Certain facts however emerge from the trials.

The Passion group stands high in winter hardiness and resistance to Botrytis. The sub-group of Stanstead Park lettuces is pre-eminent in this respect, giving an average of 71% survival (of three varieties) in the first trial. In the second trial the one planting gave 52% survival.

The main Passion group, comprising lettuces resembling Arctic and Arctic King, gave 45% survival (of eleven varieties) in the first trial, and 49% survival (of four varieties) in the second.

Imperial, an aberrant member of the Passion group of considerable market value, was less noteworthy in its survival rate, giving 16% in the one, and 34% in the other trial.

The varieties of the Lee's Immense and the All The Year Round groups, on the other hand, are more variable in their response, giving somewhere between 30 and 50% survival.

MacHattie's Giant and its synonyms gave in 1935-36 a uniform survival of about 42%. They are not, however, very satisfactory lettuces for modern market requirements.

The May Queen lettuces survived in both trials to an average extent of about 35% although they are more properly classed as spring lettuces.

The Trocadero varieties appear to be regarded as satisfactory winter-hardy varieties in the Eastern Counties but are seldom grown in the West for maturing in spring. Eight of this group were included in the 1935-36 trials. They survived the winter fairly satisfactorily but readily succumbed to Botrytis in March and April and had a final average survival rate of only 29%.

Greenhouse Trials.

Small greenhouse trials were laid down in the winter of 1936-37 to ascertain the relationship, if any, between manurial treatment and Botrytis attack.

The plots, which were each in duplicate, measured 4ft. by 3½ft. The manurial applications, indicated in Table III, were put on, in solution except in the case of steamed bone flour, on December 8th, 1936. Lettuces were planted in the plots on December 12th. There were six plants of each of four forcing varieties in each plot, except where indicated.

A very severe *Botrytis* attack eliminated completely all possible differences due to fertilisers. Counts of the lettuces surviving are given in Table III. It will be seen that the variety Cheshunt Early Giant offered some resistance to the disease.

TABLE III.

TRIAL OF GREENHOUSE LETTUCES IN RELATION TO FERTILISERS, 1936–37.

Treatment.	*Nos. of Plants surviving out of* 6.			
	Resistant Early French Frame.	*Loos Tennis-ball.*	*Golden Ball.*	*Cheshunt Early Giant.*
1. Control.	0 (out of 5)	2 (out of 5)	3 (out of 5)	2 (out of 5)
	0	0	1	3
2. Ammonium sulphate (6 cwt. per acre).	0	0	0	1
	0	0	0	1
3. Steamed bone-flour (4 ozs. per square yard).	1	0	0	3
	1	0	1	2
4. Control.	2	0	3	2
	0	0	0	3
5. Borax (20 lbs. per acre).	3	0	2	2
	0	0	0	3
6. Ammonium sulphate (6 cwt. per acre).	0	0	0	2
	0	0	0	1
7. Control.	1	0	0	0
	1	0	1	3
8. Sulphate of potash (3 cwt. per acre).	0	0	0	2
	3	0	1	3
9. Ammonium sulphate (3 cwt. per acre).	0	0	1	5
	0	0	0	0
10. Manganese sulphate (40 lbs. per acre).	1	0	1	1
	0	0	0	0
Total survival (out of 119).	13	2	14	39

DISEASES OF ONIONS.

White Rot.

White Rot of Onions, caused by *Sclerotium cepivorum*, is widely distributed throughout the Bristol Province, occurring mainly on spring or bunching onions of the "White Lisbon" variety. It is occasionally epidemic, as in the autumn of 1937, when entire fields of these onions were wiped out in the Evesham district and around Bristol. In one case the ground had been free from onions for at least eight years.

The conducive factor in this case appears to have been drought and high soil temperatures during the late summer.

Trials in 1934-35, with ten new proprietary substances likely to prove useful as soil disinfectants against this disease, showed that two proprietary organic mercury compounds, one containing 20% and the other 8% metallic mercury, were markedly effective and non-injurious to the seeds and subsequent plants.

In 1936-37, trials were carried out with the application of one of these, a proprietary organic mercury compound (stated to contain hydroxymercurichlorophenol with 20% organically combined mercury), to the soil prior to sowing the onions.

Two out of four trials were sufficiently infected to yield results of value. The details are given below.

Trial 1. *Offenham, Worcs.*

Lay-out. Eight randomised plots each 4 square yards in area.

Treatment. Applications of the dust made July 24th, 1936. Dust mixed with fine, dry soil, shaken evenly over plots and raked in.

Sowing. Seed (White Lisbon) sown August 8th, 1936.

Results. Counts of diseased and healthy plants made on June 9th, 1937, with the following results :—

No. of Plot.	*Treatment.*	*Diseased Plants.*	*Healthy Plants.*	*Total No. of Plants.*	*% Diseased Plants.*	
1.	¼ oz. per sq. yd. ..	303	31	334	90.7	
2.	½ oz. ,, ..	258	174	432	59.7	
3.	¾ oz. ,, ..	219	111	330	66.3	
4.	1 oz. ,, ..	393	298	691	56.8	
5.	Control	381	26	407	93.6	Av. 86.7
6.	Control	259	65	324	80.0	
7.	Control	258	41	299	86.3	
8.	Control	432	65	497	86.9	

Trial 2. *Cheltenham.*

Lay-out. Eight randomised plots each 4 square yards in area.

Treatment. Applications of the dust made July 27th, 1936, in the same way as at Offenham.

Sowing. Seed (White Lisbon) sown August 5th, 1936.

Results. Counts of diseased and healthy plants made June 11th. 1937, with the following results :—

No. of Plot.	*Treatment.*	*Diseased Plants.*	*Healthy Plants.*	*Total No. of Plants.*	% *Diseased Plants.*	
1.	¼ oz. per sq. yd. ..	205	25	230	89.1	
2.	½ oz. ,, ..	209	61	270	77.4	
3.	¾ oz. ,, ..	73	242	315	23.1	
4.	1 oz. ,, ..	62	284	346	17.9	
5.	Control	262	20	282	92.9	Av. 90.4
6.	Control	203	30	233	87.1	
7.	Control	242	26	268	90.3	
8.	Control	226	21	247	91.5	

Little white rot was noticed in any of the trials till May, 1937. The hot and dry weather in April was apparently conducive to the fungus, with the result that the disease became very marked about a fortnight afterwards. It was noticed that plants under the shade of adjoining plum trees were unaffected.

In the Cheltenham trial the control plots looked very brown and withered, while the treated plots remained green, except for a few shrivelled plants at the edges.

To summarise the results there was about 72% reduction in infection by the use of the heaviest dressings at Cheltenham, and 30% reduction at Offenham.

Onion Smut.

By special permit from the Ministry of Agriculture a trial of the effect of organic mercury and cuprous oxide seed dressings on the control of onion smut was carried out near Evesham in June, 1937. The mercury materials used were a methyl mercury nitrate dust, containing 0.7% Hg as methyl mercury nitrate, and a methyl mercury phosphate dust containing 0.81% Hg. An excess of the dusts was used. The mercury dusts did not adhere satisfactorily to the seeds but the cuprous oxide adhered well.

Although the seedlings became heavily infected no noticeable difference was observed in the amount of smut in treated and control plots.

REFERENCES.

(1) Grainger, J. The Appearance of Bean Mosaic in England. *Proc. Leeds Phil. Soc.* (*Sci. Sect.*) 2, p. 32, 1929.

(2) Hobbis, E. W., Ogilvie, L. and Hickman, C. J. Winter Lettuce Trials. *Worcs. County Council Quart. Agr. Chron.*, 5, No. 4, p. 201, 1937.

(3) Ogilvie, L. and Mulligan, B. O. Progress Report on Vegetable Diseases, III. *Ann. Rept. Agr. and Hort. Res. Stn., Long Ashton*, p. 119, 1931.

(4) Ogilvie, L. and Mulligan, B. O. Progress Report on Vegetable Diseases, IV. *Ann. Rept. Agr. and Hort. Res. Stn., Long Ashton*, p. 103, 1932.

(5) Ogilvie, L. and Mulligan, B. O. Progress Report on Vegetable Diseases, V. *Ann. Rept. Agr. and Hort. Res. Stn., Long Ashton*, p. 98, 1933.

(6) Pugsley, A. T. Halo Blight of Beans. *Journ. Dept. Agr. Victoria, Australia*, 34, 6, p. 311, June, 1936.

(7) Wager, V. A. Bacterial Wilt and Blight of French Beans. *Union of South Africa, Dept. of Agr. and For., Science Bull.* 149, 1936.

CEREAL DISEASES IN THE BRISTOL PROVINCE.

By L. OGILVIE.

The increase in wheat growing in recent years following on the wheat quota has given an added interest and importance to diseases affecting cereal crops, which has been reflected in the increased number of enquiries submitted to County Agricultural Staffs and the Advisory Mycologist.

Although the Bristol Province includes the important wheat regions of the Cotswolds and the Wiltshire Downs and the barley area of the Vale of Taunton comparatively little was known, until recently, of the diseases occurring on these crops. In the opinion of the writer the climatic and soil features of the Province, differing as they do so markedly from those of the Eastern Counties, may be associated with aspects of these diseases which are peculiar to the South-West.

The object of the present paper is to supply information on the cereal diseases recorded in the Province, and on the means available for their control.

Diseases of Wheat.

"Take All."

This is the popular name of a disease which has caused considerable concern to growers in this area during recent years. The name originated in Australia where the trouble is often very serious and may cause a total failure of crop.

In this country the main symptoms are poor growth and the development of thin, faulty or discoloured ears. The weak plants may occur in well defined patches or may be scattered, more irregularly, throughout the fields.

The disease is caused by a fungus, *Ophiobolus graminis*, which attacks the roots and stem bases. The chief diagnostic feature is the black velvety weft of fungus threads which may be found at the extreme base of the stem beneath the leaf sheaths.

"Take All" has been recorded from all the counties which comprise the Bristol Province, but is especially prevalent and severe in the limestone areas. It was severe in several localities in Gloucestershire in 1933. In 1935 it was epidemic throughout the Province. In 1937 a large number of cases were brought to the notice of the writer, and as County Agricultural Staffs became familiar with the symptoms more and more cases became evident.

The response of the disease to various environmental and cultural factors has suggested ways in which the disease may be kept under control.

It has been found that the fungus can persist in the soil only on dead roots or stems of susceptible plants. Wheat is very susceptible, barley less so, while oats are seldom attacked. As long rotations as possible should therefore be given between wheat and wheat or barley.

Recent investigations have shown that the roots of some grasses can be affected without any marked symptoms being evident on the tops of the plants. Rye grasses are especially susceptible, and severe outbreaks of the disease on wheat and barley after many years of ley are probably explained by the carrying over of the fungus on the roots of these plants.

The fungus can persist on dead stubble only for a few months. It is therefore most prevalent where cereal crops are grown one year after another without adequate rotation. It would seem that it is most important to plough in affected stubble quickly to allow it to decompose before another cereal crop is sown. Bare summer fallows are especially valuable in this respect.

The growth of the fungus is favoured by alkaline soils and the disease is therefore most troublesome in the limestone districts. In other countries it has been found that the use of acid fertilisers, such as superphosphate and sulphate of ammonia, lessen it somewhat. In the South-West there are many farmers who consider that severe attacks are usually associated with deficiency of phosphates or nitrogen, but one has to remember that these deficiencies can cause poor growth of themselves, apart altogether from any question of disease. The texture of the soil is also correlated with prevalence of the disease. It appears to be most prevalent in thin soils with an open texture, and in Australia one of the chief methods of control is the preparation of a firm seed-bed (2).

In Australia superphosphate is also drilled with the seed and seems to have a considerable effect in checking the disease, probably by promoting root development.

Lodging.

A disease which is liable to be confused with Take All has come into prominence during the last season. It is being worked on by investigators at Rothamsted. Unfortunately no popular name has yet been attached to it, but it may be referred to here as the "lodging" disease, since lodging is one of its most important symptoms. In Germany it is known as "Halmsruchkrankheit" (straw breaking disease).

The disease is caused by the fungus *Cercosporella herpotrichoides*, which causes at first oval or eye-shaped spots at the bases of the stems early in the season. Later, a black velvety mass of fungus is formed under the leaf sheaths, very like *Ophiobolus*. The disease may be distinguished from Take All at this stage, however, by the following characteristics. The roots are not blackened as in Take All; grey mycelium of the fungus is usually found inside the hollow bases of the stems; and affected stems break across very easily so that lodging occurs. It is probable in fact that much of the lodging ascribed to excessive nitrogen is really due to this disease.

During 1937, this "lodging" disease was found in several parts of Wiltshire, and the fungus is probably widespread. Little is known of any effective control measures against it. It would seem that it is not so readily controlled by long rotations and bare fallows as is Take All. Thus, in a case at Devizes, it occurred on wheat in a four year rotation, and after a long fallow. The land had clover ley ploughed up in May and summer fallowed. Wheat was then sown in November. In another case, at Shrewton, the disease was prevalent on wheat sown in October, following oats and vetches ploughed in as green manure.

Black Rust.

Black rust, caused by *Puccinia graminis*, is very common throughout the Province, and probably no district in the area is free from it. The rust is easily distinguished from the brown and yellow rusts, which also occur on wheat, by the fact that its autumn stage occurs in long black stripes on the stems, breaking through the epidermis. It has also been found on the glumes in our area.

If the wheat becomes infected early the development of the ears is checked and they are finally thin and discoloured. Thus anything which delays ripening, such as late sowing (the disease is worse on spring wheats), the use of late maturing varieties, cold spring weather, or highly nitrogenous conditions will increase the severity of the symptoms. The spread of the summer spores is favoured by hot weather with rain or dews.

As is well known Black Rust has an alternate stage on the common Barberry (*Berberis vulgaris*). Although the barberry appears to be fairly common in Wales it is rarely found throughout most of our area, and another explanation of the survival and prevalence of the disease here must be sought.

The rust may possibly overwinter on wheat in its uredo or summer stage, although this appears to be rather unlikely under the climatic conditions which prevail in England in winter. Another explanation is that summer spores are carried in the upper air from the Continent and that our wheat fields finally become infected in this way, just as the wheat growing regions in Canada and the northern parts of the United States become infected every year by means of spores blown from the States bordering on the Gulf of Mexico.

Brown and Yellow Rusts.

Brown Rust, caused by *Puccinia triticina*, and Yellow Rust, caused by *P. glumarum*, are both prevalent every summer, becoming common during May. Under conditions which delay ripening of the plants, referred to under Black Rust, Yellow Rust, especially, may become so prevalent as to check the development of the ears. It may also occur on the glumes, as in Wiltshire in 1937.

It is probable that both these rusts overwinter on the leaves of wheat in the South-West since the summer spores (uredospores) can withstand frost. Thus in November 1937 brown rust was found to be abundant on self-sown wheat in a field near Bridgwater. The summer spores of yellow rust are sensitive to high temperatures and affected wheat may therefore " grow away " in warm summers.

Rivet and Little Joss are resistant to yellow rust, while Squareheads Master and Yeoman are moderately susceptible. Wilhelmina (Victor) is reported to be markedly susceptible.

The variety Chinese White is very resistant to brown rust and is being used in hybridisation.

Mildew.

Mildew, caused by *Erysiphe graminis*, appears to be rather severe in some years in Worcestershire. Like the rusts, it can bring about a severe check to growth. When prevalent it is sometimes found on the glumes. It is often found on shaded or excessively manured crops.

Bunt.

Bunt or Covered Smut (*Tilletia Caries*) is now less common than formerly, owing to the greater care taken in seed selection and the more extensive use of organic mercury dusts. These dusts give a practically complete control of bunt, since they kill spores adhering to the surface of the seeds.

Loose Smut.

This disease, caused by the smut fungus *Ustilago Tritici*, is rather prevalent in the wheat fields in certain seasons. For example it was common in North Wilts in 1936. It is easily recognised by the masses of spores, these being loose and exposed.

In this case the spores are carried from flower to flower, and the fungus penetrates to the young grain and develops inside it. Cold and wet weather, which delays the maturation of the flower and favours spore germination, may lead to a considerable spread of the disease and infection of the grain, which is apparent in the following season. Loose smut is more severe in spring sown wheats because temperatures at that time favour the growth of the fungus within the grain.

It is impossible to reach the fungus inside the grain by chemical means, and the only satisfactory control measure available is to soak the seed in cold water for four hours and then in warm water at 125°–129°F. for 10 minutes. The operation has to be performed carefully to avoid damage, and it is therefore advisable to obtain seed from a crop free from loose smut.

Glume Blights.

Discolouration of the glumes and ears is frequently associated with damage by the Take All fungus, which checks their development. As mentioned above, black and yellow rusts and mildew may also occur on the ears.

There is a specific fungus, *Septoria nodorum*, which is associated with spotting of the glumes. It is very common and widespread in the South-West, and in wet seasons probably causes more damage here than in the Eastern counties.

Brown Neck.

Occasionally wheat stems are affected with a brown discolouration just below the ears. The trouble does not appear to be at all common in the South-West. Its cause is unknown.

Diseases of Oats.

Take All.

Take All rarely affects oats and hence oats may usually be regarded as a safe crop to precede wheat.

Leaf Spot and Seedling Blight of Oats.

This disease, caused by the fungus *Helminthosporium Avenae*, is common in the wet and cold districts of Great Britain, and is liable to be severe in the Bristol Province during wet and cold winters. Thus in 1936 it was common in Somerset. Seed from badly diseased crops carries the fungus near the tip of the grain and the emerging shoot becomes infected, often so badly that the seedling dies off. A later stage of the trouble becomes noticeable in the summer when the leaves become covered with long brown spots.

Organic mercury seed dressings give very effective control by killing the fungus on the seeds and so protecting the seedlings.

Loose Smut.

Loose smut of oats is known to every farmer. It is sometimes rather prevalent in the South-West ; thus a case of 20% infection was recorded in 1934, and one of 50% infection in 1935.

The oat spikelets are transformed into black powdery masses of spores. These adhere to healthy flowers and form a fungus mass round the seed coat which eventually infects the young shoots as they emerge. The fungus (*Ustilago Avenae*) then grows up in the tips of the shoots and becomes evident again at harvest time.

Up to recently there was some doubt regarding the effectiveness of the control of loose smut of oats by organic mercury seed dressings, but recent work has shown that the disease may sometimes be controlled effectively by these dusts (1, 3).

Crown Rust.

The common rust of oats, Crown Rust, *Puccinia Lolii*, is sometimes common and severe enough to cause some check to the plants. As in the case of the rusts of wheat, however, the disease is usually not of very serious importance, except when weather conditions are such as to favour the spread of the fungus and check the growth of the plants, and when the ground is rich in nitrogen.

The alternate stage of the rust is fairly common on buckthorn (*Rhamnus catharticus*) in hedges, and it is advisable to keep this shrub down wherever possible. The rust may also possibly over-winter on wheat in the South-West.

Mildew.

Mildew (*Erysiphe graminis*) is sometimes found on oats, under rich soil conditions, and in weather favourable for the fungus. Thus it was rather severe in March, 1935.

Diseases of Barley.

Take All.

As already mentioned Take All can affect barley almost as severely as wheat, and several cases have been recorded from the Bristol Province in recent years.

Rust.

A severe case of barley rust, *Puccinia anomala*, has been associated in Wiltshire with failure of the ears. The conditions favouring the disease are the same as those which are conducive to the rusts of wheat and oats.

Smut Diseases.

There are two smut diseases of barley which are more or less readily distinguishable, namely covered smut, caused by the fungus *Ustilago Hordei* and loose smut, caused by the fungus *Ustilago nuda.* The former appears to be relatively common in the Bristol Province.

The life history of covered smut of barley much resembles that of bunt of wheat and loose smut of oats, and the disease may be controlled very well by the organic mercury seed dressings. On the other hand, infection with loose smut of barley like loose smut of wheat, takes place when the plant is flowering and the fungus penetrates right inside the grain. The most volatile seed dressings are unable to reach it, and the only method of killing it is by means of a troublesome hot water treatment. It is advisable therefore to avoid keeping seed from a barley crop infected with loose smut.

Mildew.

Barley mildew (*Erysiphe graminis*) has been recorded as rather severe in Herefordshire. The same remarks apply here as in the case of mildew of wheat and oats.

Leaf Stripe and Net Blotch.

These two diseases have both been found in Wiltshire. They somewhat resemble leaf spot of oats. In Leaf Stripe of barley, caused by the fungus *Helminthosporium gramineum*, there are long brown stripes on the leaves and the grain may entirely fail to develop. The fungus is carried over on the husk of the grain, from which the young leaves become infested.

In Net Blotch of barley, caused by the fungus *Helminthosporium teres*, there are at first rather broad, brown, net-like markings on the leaves. Eventually the leaves may be almost entirely killed off and poorly developed grains may result.

Both these diseases may be commercially controlled by organic mercury seed dressings.

Decay of Seeds Resulting in Poor " Stand."

In addition to the diseases which have been mentioned, there is another trouble which may be largely prevented by the modern seed dressings. In very wet and cold weather, and on heavy land, seeds are liable to rot off, and the farmer gets only a poor stand. This rotting off or " pre-emergence damping off " is due to fungi in the soil attacking the seeds. The organic mercury seed dressings form a protective layer round the seed coat, and also probably sterilise a small area of soil round the seed, so preserving it effectively till the young shoot appears.

Summary.

The diseases occurring on wheat, barley and oats in the counties of Gloucester, Hereford, Somerset, Wiltshire and Worcester, comprising the Bristol Advisory Province, are described briefly and control measures suggested in each case.

REFERENCES.

(1) Dillon Weston, W.A.R,, Hanley, F. and Booer, J. R. Seed Disinfection. II. Large-scale Field Trials on the Disinfection of Seed Corn with Mercury Dust Disinfectants. *Journ. Agri. Sci.*, XXVII, p. 43, 1937.

(2) Samuel, G. Whiteheads or Take All in Wheat. *Journ. Min. Agri.* XLIV, p. 231, 1937.

(3) Muskett, A. E. and Cairns, H. The Effect of Seed Disinfection upon the Oat Crop in Northern Ireland. *Ann. Appl. Biol.* XIX, p. 462, 1932.

THE EFFECT OF FERTILISERS ON PEAS AFFECTED WITH "PEA SICKNESS."—POT EXPERIMENTS.

By L. OGILVIE, C. J. HICKMAN and C. L. WALTON.

In the Reports of the Long Ashton Research Station for 1935 and 1936, pot and field experiments were described which indicated clearly that the yield of potato tubers could be greatly increased when dressings of nitrogenous fertilisers, such as sulphate of ammonia and calcium cyanamide, were added to " sick " potato soil, *i.e.* soil infested with the eelworm *Heterodera schachtii.* Cyst counts, unfortunately somewhat incomplete, seemed to indicate that no reduction in cyst population on the roots accompanied this result.

The pot experiments described herein were designed to ascertain whether, in eelworm infested soil, similar effects to those with potatoes would result on peas from the application of a nitrogenous fertiliser, such as nitrochalk, and to determine whether any effects would be produced by phosphate and potash applied as superphosphate and sulphate of potash respectively.

Review of Recent Work.

Previous to 1934 various workers, such as Edwards, Davies, Miles, Carroll and Hodson, had found that markedly increased yields of potatoes on " sick " land resulted from applications of calcium cyanamide. In the Long Ashton Annual Report for 1934 (8) Walton, Ogilvie and Mulligan described preliminary experiments on the effect of calcium cyanamide on pea sickness. The results indicated that applications of this chemical, at 10 cwt. per acre, may result in normal cropping. There was no evidence of any marked reduction of the cyst population on the roots.

In the course of experiments in 1935 (9) Walton, Ogilvie and Brian again found that normal crops of peas were produced on eelworm infested soil following the application of calcium cyanamide at 10 cwt. per acre. In the case of potatoes a similar result was obtained with the cyanamide, and an application of urea in conjunction with lime, supplying nitrogen equal to 10 cwt. of cyanamide, also resulted in a normal crop of tubers. In both cases, although no actual counts were made, eelworm cysts were very prevalent on the roots. It was considered therefore that the good results following applications of calcium cyanamide at the rate of 10 cwt. per acre were not due to any lethal effects of the chemical on the eelworms but to supplying nitrogen to the " sick " plants.

In the same year, Hurst and Triffitt (3) carried out pot experiments with sulphur, naphthalene, basic slag, kainit, superphosphate, muriate and sulphate of potash, sulphate of ammonia and calcium cyanamide. These investigators were searching primarily for a substance which would reduce the eelworm infestation of the roots and bring about a control in this way. None of the substances in question except calcium cyanamide were considered to show promise of reducing the eelworm content of infected soil and they were therefore not considered further. It was stated, however, that the response of the plants to the soil containing heavy dressings of nitrogen was conspicuous in all cases and that in the series with ammonium salts and potassium nitrate the plants which received the heavy dressings of nitrogen were conspicuously the best in appearance. No crop weights were obtained.

In 1936, Walton, Ogilvie and Hickman (10) to elucidate further the theory that the effect of eelworm infestation on the plants is to starve them of nitrogen and that this deficiency can be made up by treatment with nitrogenous fertilisers, laid down a field experiment to determine whether sulphate of ammonia, at rates equivalent to 3 and 10 cwt. of calcium cyanamide per acre respectively, would have similar effects to these dressings. In this experiment it was found that the yield increases from equivalent dressings of sulphate of ammonia and cyanamide were similar and that the cyst numbers on the roots were apparently unaffected. Chemical analyses of healthy and eelworm affected plants from each plot were made and the important point was brought out that in every case the healthy plants contained a higher percentage of nitrogen in the young leaves than the corresponding diseased plants.

In 1937, Hurst and Franklin (4) applied a heavy dressing of calcium cyanamide (30 cwt. per acre) to potato sick soil and obtained increased yields, though less striking than those described above. They found that the increase of cysts in the soil after lifting the crop was small on the treated plots in comparison with the control plots.

In 1936, Hurst and Triffitt (5) also showed that in pot experiments heavy dressings of calcium cyanamide, equivalent to 20 cwt. per acre and over, brought about marked reductions in cyst numbers on the roots of the plants compared with control plants. Equal dressings of urea also caused a reduction of cysts on the roots in comparison with control plants, a result attributed to a retarding action on the hatching of the larvae.

Edwards (2), in 1936, found a progressive increase in yield of tubers on potato sick soil from dressings of calcium cyanamide up to 20 cwt. per acre. With dressings greater than 20 cwt. per acre the yields decreased owing to retardation of development or even total destruction of many of the plants. Cysts developed profusely on the roots after dressings of 10 and 20 cwt. per acre, but dressings of 40 cwt. per acre reduced their number greatly. Edwards considered that the use of calcium cyanamide in heavy dressings was likely to prove the most satisfactory means of protecting potato crops from " sickness " and simultaneously clearing infested land of the nematode.

It will be gathered from this review that there are two possible methods of dealing with " sickness " caused by the eelworm : (1) by feeding the plants every year with nitrogenous fertilisers so that the nitrogen deficiency brought about by the eelworm infestation is nullified, a method which is simple and inexpensive, and (2) by heavy applications, 20 cwt. and over, of calcium cyanamide, whereby eelworm cysts on the soil are actually killed. This method, favoured by most investigators, has the disadvantages of expense, reduced yields for the first year, and very doubtful effectiveness subsequently.

Blenkinsop (1), working on potato sickness in Devon and Cornwall, has demonstrated that in that area the symptoms are associated with a low potash-phosphate ratio in the soil. He considers, however, that low nitrogen ratios may sometimes be involved.

Experimental.

The soil used in the experiment was obtained from a plot at Berkeley School, Glos., where field experiments on " pea sickness " had been carried out in previous years. About 1 ton of soil was taken from areas which had served as control plots in the former experiments. The bulk was thoroughly mixed, dried and sieved, and placed in 10 inch pots, each pot containing 18 lbs. of soil. One hundred and twenty experimental pots were thus obtained. The pots were subsequently divided into two groups of 60. On June 25th and 26th, 1937, the pots of soil in one group were steam sterilised after having been watered thoroughly. On July 6th, both sterilised and unsterilised pots were placed in the Research Station pot enclosure. Sufficient water was then added to the unsterilised pots to obtain approximately the same water content in both sterilised and unsterilised soils.

Each group of 60 pots was divided into four series of 15, and these received different manurial treatments as folllows :—

Series 1. No treatment.
,, 2. Superphosphate, 10 grams per pot (roughly equivalent to 25 cwt. per acre); sulphate of potash, 8 grams per pot (20 cwt. per acre).
.. 3. Nitrochalk, 8 grams per pot (20 cwt. per acre); superphosphate (as in 2).
.. 4. Nitrochalk, superphosphate and sulphate of potash (as in 2 and 3).

The fertilisers were added to the surface of the soil of each pot on July 7th and mixed with the top 2—3 inches of soil.

Peas of the variety Surprise were sown, ten to each pot, on July 12th, the resulting seedlings being reduced to three per pot on July 26th.

Results and Discussion.

On September 22nd, when the majority of the plants had reached maturity and were bearing pods, and during the next few days, growth data were taken and samples of soil collected from each pot for estimating cyst numbers.

Growth Data.

Appearance of plants. In the sterilised soil group there were no apparent differences between any of the four series, all the plants being strong and uniformly blue green in colour, suggesting highly nitrogenous conditions. In the unsterilised group the plants in the two series receiving nitrogen were a darker green in colour and had made more growth than those in the other two series, the plants in the two latter series being pale, yellowish green in colour and very spindly. In contrast to the plants in the sterilised soil group, there was some dying off and shrivelling of the lower leaves in all four series of the unsterilised soil group.

Crop Records.

Data were collected relating to fresh weight, and subsequently dry weight, of haulm plus pods and length of haulm from each pot in each of the four series. The summarised results are given below in Tables I and II.

TABLE I.

HAULM PLUS POD WEIGHTS IN GRAMS PER POT.

Treatments.	*Sterilised Soil.*		*Unsterilised Soil.*	
	Fresh Weight.	*Dry Weight.*	*Fresh Weight.*	*Dry Weight.*
1. No manure	69.0	11.8	24.9	4.08
2. Phosphate and potash ..	97.5	16.06	17.4	3.4
3. Nitrogen and phosphate ..	75.0	12.7	41.1	6.05
4. Nitrogen, phosphate and potash	86.4	14.2	42.1	5.8
Significant difference (dry weight)		5%—2.048 1%—2.763		5%—0.9 1%—1.3

In Table I the dry weight figures in each group have been statistically analysed. In the sterile soil group, the phosphate-potash and the nitrogen-phosphate-potash treatments have given significant increases in weight over the no manure treatment, the former to the 1% point and the latter to the 5% point. The increase in weight from the nitrogen-phosphate treatment is not significant. The phosphate-potash treatment also shows a significant increase in weight, to the 1% point, over the nitrogen-phosphate treatment and an almost significant increase over the nitrogen-phosphate-potash treatment.

The results thus show that the increases in treatments 2 and 4 are due to potash and also suggest that the addition of nitrogen was injurious, a result which might be expected in a newly-sterilised soil. The effect of the phosphate application cannot be determined but could not have been large.

In the unsterilised group the nitrogen-phosphate and the nitrogen-phosphate-potash treatments have given increases in weight significant to the 1% point over the no manure treatment. The phosphate-potash treatment shows a decrease in weight which however is not statistically significant, and it seems clear that neither potash nor phosphate have increased yields in this series.

TABLE II.

HAULM LENGTH IN INCHES PER POT.

Treatment.	*Sterilised Soil.*	*Unsterilised Soil.*
1. No manure	44.7	35.1
2. Phosphate and potash ..	64.8	33.5
3. Nitrogen and phosphate ..	51.9	42.7
4. Nitrogen, phosphate and potash	54.3	41.7
Significant difference ..	5%—6.14 1%—8.29	5%—4.8 1%—5.5

In Table II in the sterile soil group, the phosphate-potash and the nitrogen-phosphate-potash treatments have given increases in haulm length, significant to 1%, and the nitrogen-phosphate treatment, an increase significant to 5% over the no manure treatment. The phosphate-potash treatment has given a significant increase to the 1% point over both nitrogen-phosphate and nitrogen-phosphate-potash treatments. This result supports the view that nitrogen adversely affected growth in this group.

In the unsterilised soil group, the statistical differences between treatments are of the same order as in the case of haulm plus pod weights, nitrogen being responsible for increases over the corresponding no nitrogen treatments to the 1% point in both cases.

The results for the sterilised and unsterilised soils may now be considered together. In the former case, they show that the soil was deficient in potash and the plants re-acted significantly to this constituent in the fertilisers. This deficiency, in absence of evidence to the contrary, can reasonably be assumed as a natural one and not to be due to the sterilising process. Lawrence and Newell (5) obtained no evidence of sterilisation rendering composts deficient in potash. The adverse effect for nitrogen addition in the group, if real, can be discounted in view of the known nitrogenous effect which follows from sterilisation.

In the unsterilised soil, increases only followed from dressings of nitrogen, and it may thus be concluded that potash was quite ineffective in the presence of the eelworm, even under conditions of potash deficiency, whilst nitrogen, given as nitrochalk, was to some extent capable of counteracting the effects of the eelworm. The latter result is in harmony with our previous findings (8) and the former is contrary to the results of Blenkinsop with potatoes in Devonshire (1).

Cyst Counts.

The methods employed for counting cysts in the soil were those described by Morgan (6) and Hurst and Franklin (3). Two samples of 50 grams were examined from each pot, a total of thirty samples per treatment.

Average Number of Cysts in 50 Grams Soil.

Treatment.	*Cyst Number.*
1. No manure	91
2. Phosphate and potash	93
3. Nitrogen and phosphate	99
4. Nitrogen, phosphate and potash ..	85

The differences between the cyst counts from the treated series and that from the no manure series are not statistically significant. In the previous experiment on "potato sickness" (8), cyst numbers on roots of mature plants, so far as they were examined, also showed no reduction under the application of nitrogenous fertilisers. In the present case, using a different method of estimating their number, a statistical analysis shows no significant difference in the final cyst population from different manurial treatments. In this experiment it would therefore appear that nitrogen has produced beneficial effects without causing a change in the eelworm population.

No evidence of increased eelworm population was found with increased vigour as reported by Edwards (2).

Conclusions and Summary.

1. Pot experiments with *Heterodera schachtii* were carried out with peas, variety Surprise, to examine the effects of fertiliser treatments on plant growth and on the eelworm population. The soil used was heavily infested with the eelworm. For the experiment, half of it was steam sterilised to destroy the eelworm and the other half left without this treatment. The following fertiliser treatments were given to both lots of soil :—no manure, superphosphate and potash, nitrochalk and superphosphate, and nitrochalk, superphosphate and potash.

2. The following conclusions were drawn :—

(*a*) Growth increases from potash manuring in the sterilised soil group showed that the soil was naturally deficient in potash. In this group the addition of nitrogen was probably detrimental.

(*b*) Nitrogen was the only constituent to effect growth increases in the unsterilised soil group, potash being without effect even under conditions of natural deficiency of this constituent.

(*c*) None of the fertiliser treatments affected the eelworm population.

(*d*) The results, like those obtained in 1936, suggest that eelworm infestation interferes with the nitrogen metabolism of the plants. The addition of nitrogen at the rate given had no effect on eelworm infestation but enabled the plants to obtain normal supplies of this element.

These results confirm our opinion previously arrived at that the application of relatively small quantities of nitrogenous fertilisers is a practical method of obtaining normal crops from eelworm infested soil.

Acknowledgment.

The writers wish to express their indebtedness to Dr. T. Wallace for valuable advice on the conduct of the trial and interpretation of the data.

REFERENCES.

(1) **Blenkinsop, A.** " Observations on Potato Sick Soils in Devon and Cornwall." *Journ. Min. Agric.*, 41, pp. 1187-1189, 1935.

(2) **Edwards, E. E.** " Experiments on the Control of the ' Potato Sickness ' associated with the Nematode *Heterodera schachtii.*" *Journ. Helminth,* 15, 2, pp. 77-96, 1937.

(3) Hurst, R. H. and Triffitt, M. J. "Calcium Cyanamide and other Artificial Fertilisers in the Treatment of Soil infected with *Heterodera schachtii*." *Journ. Helminth.*, 13, 4, pp. 201-218. 1935.

(4) Hurst, R. H. and Franklin, M. T. "Field Experiments in Lincolnshire on the Chemical Treatment of Soil infected with *Heterodera schachtii*." *Journ. Helminth.*, 15, 1, pp. 9-20, 1937.

(5) Hurst, R. H. and Triffitt, M. J. "Further Experiments on the Chemical Treatment of Soil infected with *Heterodera schachtii*." *Journ. Helminth.*, 15, 1, pp. 1-8, 1937.

(6) Lawrence, W. J. C. and Newell, J. "Seedling Growth in partially Sterilised Soil." *Scient. Hort.*, 4, pp. 165-177, 1936.

(7) Morgan, D. O. "Investigations on Eelworm in Potatoes in South Lincolnshire." *Journ. Helminth.*, 3, 5, pp. 185-192, 1925.

(8) Walton, C. L., Ogilvie, L. and Mulligan, B. O. "The Effect of Calcium Cynanamide and of Formalin on Pea 'Sickness'." *Ann. Report. Agric. and Hort. Res. Stn., Long Ashton, Bristol*, pp. 158-161, 1934.

(9) Walton, C. L., Ogilvie, L. and Brian, P. W. "The Effect of Calcium Cyanamide on Pea and Potato 'Sickness'". *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton, Bristol*, pp. 91-97, 1935.

(10) Walton, C. L., Ogilvie, L. and Hickman, C. J. "The Effect of Nitrogenous Fertilisers on Potatoes affected with Potato 'Sickness'". *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton, Bristol*, pp. 149-155, 1936.

CIDER MAKING TRIALS FOR THE SEASON 1936-1937.

By P. T. H. PICKFORD.

The 1936 cider apple crop was heavy in most districts. In Dorset, Gloucestershire, Herefordshire and Worcestershire the crop was more than double that of the previous year, and in all of the remaining counties concerned a considerable increase on the 1935 crop was recorded.

The average specific gravity of all the juices examined at Long Ashton was 1.0469. This was the lowest average since the 1930–1931 season when this value was also recorded.

The quality of the ciders and perries was considered to be very fair on the whole, in spite of the rather low original gravities. Although a big proportion of the juices lacked fullness of flavour they were pleasant in taste and made good average cider and perry.

Competitions were arranged on similar lines to those of previous years and a record number of entries was submitted. In view of this it was not possible to undertake many trials of varieties outside the competition entries, and only two such lots were accepted, these being as follows :—

Angile Grise. This very old French variety was sent from Hereford. It had a very keen, bitter character, but the tannin flavour was not unpleasant. It proved to be a very useful bittersweet for blending purposes.

Italy Bittersweet. This variety was sent from the Tenbury district of Worcestershire. It has often been confused with the variety Cherry Norman. Although the apple is very similar to Cherry Norman in colour it is distinctly conical in shape and ripens later in the season. The trial was made with fruit from young trees. The cider was considered to be good quality, somewhat similar to Cherry Norman but not so full in flavour and less soft in tannin character.

The Cider Competitions.

For the twelfth year in succession these competitions constituted one of the main features of the programme of work in the cider house. They were arranged on similar lines to those described in previous reports with the following modifications. The sharp varieties were divided into two classes according to their acidity, and the bittersweets were separated into three classes on the basis of their normal tannin content. In each class a special prize was awarded for the best variety which had not previously obtained a prize in the competitions.

An additional feature connected with the competitions was the awarding of special prizes for the consignments of fruit received in the best condition, an account of which is given elsewhere in the journal (pp. 155—159).

One hundred and ninety-nine entries were received, of which 174 were apples and 25 pears.

The competitions were open to growers residing in the same group of counties as listed for previous years, the entries from the individual counties being as follows :—Devon, 17 ; Gloucester, 30 ; Hereford, 40 ; Monmouth, 29 ; Somerset, 71 ; Worcester, 12.

The ciders were judged on April 20th, 1937, by Dr. H. V. Taylor, Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W.1 ; Mr. R. Henley (Henley & Sons Cyder Co.), Newton Abbot, Devon, vice Mr. R. Whiteway (Whiteways Cyder Co., Ltd.), Whimple, Devon ; Mr. Hartley Williams (Messrs. Williams Bros.), Backwell, near Bristol. The perries were judged on the same day by Mr. J. W. Pullin (Messrs. Pullin Bros.), Compton Greenfield, near Bristol. They reported as follows :—

" The judging of the ciders and perries in these competitions took place on April 20th, 1937.

Although the ciders and perries were somewhat lacking in body, they were, on the whole, very pleasant in flavour. In fact the quality was considerably higher than was anticipated, considering the rather low gravities of the fresh juices.

Class 1, for Kingston Black ciders, was numerically a strong class of 23 entries although the general quality was below average. There were no outstanding ciders in this class and the even quality of the entries made the judging very difficult.

Class 2A, for Sharp Varieties, consisted of ciders for blending purposes. There were 21 entries. The acid character of these ciders was particularly clean and although very pronounced was not too harsh. The cider that secured the first prize award was outstanding.

Class 2B, for Medium Sharp Varieties, comprised 28 entries, which included a wide range of ciders. Several of these were pleasant drinks, but many were either too acid or too soft for use unblended.

Class 3, for Sweet Varieties, comprised the large number of 36 entries, and as a whole these were of a higher level of quality than usual for this type of cider and included many good ciders. The three ciders selected for awards were especially deserving of mention.

Class 4A, for Mild Bittersweet Varieties, with its 26 entries, contained many good quality ciders with pleasant, mild tannin characters.

Class 4B, for Medium Bittersweet Varieties, comprising 17 entries, was another very good class. All the ciders mentioned in the award list well earned their place and were fuller in flavour than those of the other classes this year.

Class 4C, for Full Bittersweet Varieties, with 23 entries, was a good class on the whole, but several of those ciders with the most pronounced bitter character were lacking in body.

Class 5, for Perries, attracted 25 entries. The variation in the types of perry which this class afforded made it a very interesting though difficult group to judge.

There was no really outstanding perry in the class, although several were very pleasant in flavour. In character and body they were on the light side.

The first three awards were given to perries which, although attractive as beverages, did not possess a markedly distinctive perry flavour and astringency. In view of the large number of entries, it was recommended that a special prize be awarded to the best example of the more astringent perries of which several were shown ; this, although useful only for blending, was a very good example of its type.

In conclusion we express our satisfaction with the manner in which all the ciders and perries were made and the impartial way in which they were displayed. The uniform treatment and obvious care which had been given to each entry of this exceptionally large collection is a credit to those responsible for the work."

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 1.—KINGSTON BLACK ONLY.				
No. 1. (Curry Rivel, Som.)	1.049 (1/12/36)	M. 0.51 T. 0.15 F. 2.7	(*a*) 1.030 (2/2/37) (*b*) 1.029 (20/4/37)	Fair quality but rather hard in flavour; not sufficient character.
No. 2. (Dunkerton, Som.)	1.048 (1/12/36)	M. 0.52 T. 0.16 F. 3.0	(*a*) 0.030 (1/1/37) (*b*) 1.029 (20/4/37)	Fairly good, clean flavoured cider, but having very little character.
No. 3. (Kittisford, Som.)	1.059 (1/12/36)	M. 0.61 T. 0.20 F. 3.0	(*a*) 1.030 (27/2/37) (*b*) 1.029 (20/4/37)	Very good, fruity flavoured cider with more character than the two previous samples.
No. 4. (Llantilio Crossenny, Mon.)	1.053 (1/12/36)	M. 0.52 T. 0.14 F. 5.0	(*a*) 1.030 (22/2/37) (*b*) 1.029 (20/4/37)	Very pleasant and clean in flavour with a good aroma.
No. 5. (Cheddar, Som.)	1.049 (1/12/36)	M. 0.51 T. 0.18 F. 3.2	(*a*) 1.030 (21/1/37) (*b*) 1.030 (20/4/37)	Not very good; a slight soapy flavour.
No. 6. (Taunton, Som.)	1.054 (1/12/36)	M. 0.50 T. 0.17 F. 3.2	(*a*) 1.030 (8/2/37) (*b*) 1.030 (20/4/37)	A well balanced cider of good flavour and aroma; very fruity and pleasing.
No. 7. (Shapwick, Som.)	1.052 (1/12/36)	M. 0.53 T. 0.16 F. 3.7	(*a*) 1.030 (11/1/37) (*b*) 1.030 (20/4/37)	Quite a pleasant cider but not very full in flavour.
No. 8. (Burghill, Hereford)	1.045 (1/12/36)	M. 0.41 T. 0.14 F. 3.3	(*a*) 1.030 (24/12/36) (*b*) 1.030 (20/4/37)	Also pleasant but thin in flavour. Very low in acidity.

CLASS 1.—KINGSTON BLACK ONLY—*continued.*					
No. 9. (Bushley, Worcs.)	1.047 (1/12/36)	M. T. F.	0.45 0.14 2.0	(*a*) 1.030 (20/1/37) (*b*) 1.030 (20/4/37)	Fair quality but not outstanding.
No. 10. (Arlingham, Glos.)	1.049 (1/12/36)	M. T. F.	0.44 0.13 2.5	(*a*) 1.030 (7/1/37) (*b*) 1.030 (20/4/37)	A pleasing cider, soft and fruity in flavour.
No. 11. (Ross, Hereford)	1.049 (1/12/36)	M. T. F.	0.55 0.15 3.7	(*a*) 1.030 (28/12/36) (*b*) 1.030 (20/4/37)	Clean in flavour but without character.
No. 12. (Upton Snodsbury, Worcs.)	1.042 (4/12/36)	M. T. F.	0.45 0.13 3.3	(*a*) 1.030 (17/12/36) (*b*) 1.027 (20/4/37)	Very soft cider but not full-flavoured
No. 13. (Charlton Mackrell, Som.)	1.050 (4/12/36)	M. T. F.	0.49 0.13 6.0	(*a*) 1.030 (17/12/36) (*b*) 1.025 (20/4/37)	Rather dry and hard in flavour.
No. 14. (Hardwicke, Glos.)	1.049 (4/12/36)	M. T. F.	0.43 0.13 5.8	(*a*) 1.030 (19/12/36) (*b*) 1.029 (20/4/37)	A particularly pleasant well-balanced fruity cider with a fine aroma.
No. 15. (Burghill, Hereford)	1.046 (4/12/36)	M. T. F.	0.51 0.15 4.8	(*a*) 1.030 (18/12/36) (*b*) 1.029 (20/4/37)	Fair but rather thin in flavour.
No. 16. (Upton Snodsbury, Worcs.)	1.042 (4/12/36)	M. T. F.	0.50 0.14 3.3	(*a*) 1.030 (12/12/36) (*b*) 1.028 (20/4/37)	Of only fair quality.
No. 17. (Stourport, Worcs.)	1.044 (4/12/36)	M. T. F.	0.52 0.15 3.7	(*a*) 1.030 (22/12/36) (*b*) 1.029 (20/4/37)	Quite pleasant but without much character.
No. 18. (Vowchurch, Hereford)	1.055 (4/12/36)	M. T. F.	0.55 0.18 2.8	(*a*) 1.030 (2/3/37) (*b*) 1.028 (20/4/37)	Spoilt by a harsh acid flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 1.—KINGSTON BLACK ONLY—*continued.*				
No. 19. (Westbury-on-Trym, Glos.)	1.046 (4/12/36)	M. 0.54 T. 0.15 F. 2.8	(*a*) 1.030 (2/2/37) (*b*) 1.028 (20/4/37)	Very similar to the previous sample.
No. 20. (Norton Canon, Hereford)	1.044 (4/12/36)	M. 0.44 T. 0.15 F. 1.8	(*a*) 1.030 (6/2/37) (*b*) 1.028 (20/4/37)	Fair quality but not outstanding.
No. 21. (Barton St. David, Som.)	1.061 (7/12/36)	M. 0.52 T. 0.20 F. 4.3	(*a*) 1.030 (4/1/37) (*b*) 1.028 (20/4/37)	Only fair in quality; rather hard in flavour.
No. 22. (Norton Canon, Hereford)	1.054 (7/12/36)	M. 0.48 T. 0.17 F. 3.8	(*a*) 1.030 (2/1/37) (*b*) 1.029 (20/4/37)	Good quality cider with a pleasant flavour and aroma.
No. 23. (Wookey, Som.)	1.040 (7/12/36)	M. 0.65 T. 0.18 F. 2.5	(*a*) 1.030 (18/12/36) (*b*) 1.028 (20/4/37)	A pleasant cider but not very full.
SHARP VARIETIES.—				
CLASS 2A.—Varieties of high acidity, suitable only for blending.				
Bastard Tom Putt. (Easton-in-Gordano, Som.)	1.049 (18/11/36)	M. 0.95 T. 0.14 F. 3.4	(*a*) 1.030 (6/1/37) (*b*) 1.030 (20/4/37)	A very good cider for blending purposes with a clean fresh acid flavour.
Bran Rose. (Burghill, Hereford)	1.043 (28/10/36)	M. 0.76 T. 0.09 F. 4.4	(*a*) 1.030 (20/11/36) (*b*) 1.029 (20/4/37)	Not very full in flavour, but it had a good apple character.

CLASS 2A.—SHARP VARIETIES—*continued.*

Cap of Liberty. (Llantilio Crossenny, Mon.)	1.053 (25/11/36)	M. 0.90 T. 0.23 F. 5.0	(*a*) 1.030 (18/12/36) (*b*) 1.029 (20/4/37)	A fine flavoured cider although it was not as full as usual for this variety.
Cowards Apple. (Baltonsborough, Som.)	1.040 (18/11/36)	M. 0.72 T. 0.16 F. 5.2	(*a*) 1.030 (5/12/36) (*b*) 1.028 (20/4/37)	Thin in flavour.
Fair Maid of Devon. (Newton St. Cyres, Devon)	1.043 (4/11/36)	M. 0.69 T. 0.12 F. 6.0	(*a*) 1.030 (17/11/36) (*b*) 1.027 (20/4/37)	Rather poor quality; not very pleasant.
Fair Maid of Taunton. (Shapwick, Som.)	1.053 (14/12/36)	M. 0.98 T. 0.28 F. 3.3	(*a*) 1.030 (9/1/37) (*b*) 1.030 (20/4/37)	A cider with very little apple character and with a very hard acid flavour.
Foxwhelp. (Vowchurch, Hereford)	1.046 (6/11/36)	M. 1.03 T. 0.11 F. 9.5	(*a*) 1.030 (19/11/36) (*b*) 1.025 (20/4/37)	Very thin in flavour and with a poor acid character.
Frederick. (Monmouth, Mon.)	1.045 (17/10/36)	M. 1.14 T. 0.09 F. 6.3	(*a*) 1.030 (6/11/36) (*b*) 1.030 (20/4/37)	A good, clean-flavoured sharp cider but not very full bodied.
Frederick. (Monmouth, Mon.)	1.041 (28/10/36)	M. 1.11 T. 0.09 F. 6.7	(*a*) 1.030 (6/11/36) (*b*) 1.028 (20/4/37)	Fair in quality but not outstanding.
Frederick. (Usk, Mon.)	1.045 (28/10/36)	M. 1.13 T. 0.08 F. 7.3	(*a*) 1.030 (14/11/36) (*b*) 1.029 (20/4/37)	Harder in acid flavour and of poorer quality than the two previous samples.
Frederick. (Llangattock Lingoed, Mon.)	1.046 (28/10/36)	M. 1.18 T. 0.08 F. 3.8	(*a*) 1.030 (30/11/36) (*b*) 1.030 (20/4/37)	A good clean sharp cider with fair apple character.
Frederick. (Monmouth, Mon.)	1.043 (28/10/36)	M. 1.13 T. 0.07 F. 2.8	(*a*) 1.030 (30/11/36) (*b*) 1.030 (20/4/37)	Clean, but thin in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
SHARP VARIETIES—*continued.*				
Frederick. (Llantilio Crossenny, Mon.)	1.043 (29/10/36)	M. 1.08 T. 0.05 F. 2.6	(*a*) 1.030 (16/11/36) (*b*) 1.029 (20/4/37)	Lacking character and not very clean in flavour.
Frederick. (Dingestow, Mon.)	1.047 (4/11/36)	M. 0.97 T. 0.11 F. 3.8	(*a*) 1.031 (12/12/36) (*b*) 1.031 (20/4/37)	Not clean in flavour. The fruit was delivered in bad condition.
Frederick. (Hendre, Mon.)	1.047 (4/11/36)	M. 1.06 T. 0.08 F. 4.2	(*a*) 1.031 (11/12/36) (*b*) 1.030 (20/4/37)	Very good sharp cider with a pleasant, fresh apple flavour and aroma.
Frederick. (Raglan, Mon.)	1.043 (24/11/36)	M. 0.84 T. 0.08 F. 2.8	(*a*) 1.031 (19/12/36) (*b*) 1.031 (20/4/37)	Thin flavoured cider with very little character.
Hartisman. (Easton-in-Gordano, Som.)	1.044 (14/12/36)	M. 0.84 T. 0.18 F. 4.0	(*a*) 1.030 (22/12/36) (*b*) 1.029 (20/4/37)	Very good flavoured cider; sound in flavour with good apple character.
Hereford Redstreak. (Barton St. David, Som.)	1.043 (29/10/36)	M. 0.87 T. 0.07 F. 4.5	(*a*) 1.030 (16/11/36) (*b*) 1.028 (20/4/37)	Clean but very thin in flavour.
Tyley's Red. (Cheddar, Som.)	1.042 (13/11/36)	M. 0.89 T. 0.20 F. 6.0	(*a*) 1.030 (28/11/36) (*b*) 1.027 (20/4/37)	Poor quality, very watery in flavour.
Wagstaff. (Upton Snodsbury, Worcs.)	1.044 (12/11/36)	M. 0.62 T. 0.14 F. 4.6	(*a*) 1.030 (8/12/36) (*b*) 1.029 (20/4/37)	Fair quality cider, clean and pleasant in flavour but lacking fullness.
White Thorn Pippin. (Stonehouse, Glos.)	1.040 (10/11/36)	M. 0.89 T. 0.08 F. 9.0	(*a*) 1.030 (18/11/36) (*b*) 1.028 (20/4/37)	A cider with a very good clean acid character. Fresh in flavour; a useful blender.

CLASS 2B.—VARIETIES OF MEDIUM ACIDITY.

Betty Barton. (Tirley, Glos.)	1.047 (12/11/36)	M. T. F.	0.57 0.19 8.8	(*a*) 1.030 (21/11/36) (*b*) 1.025 (20/4/37)	Very poor quality.
Black Jack. (Wedmore, Som.)	1.046 (14/12/36)	M. T. F.	0.60 0.15 9.0	(*a*) 1.031 (21/12/36) (*b*) 1.030 (20/4/37)	Very pleasant fruity flavoured cider. A little too high in acidity to drink unblended.
Bomford's Foxwhelp. (Upton Snodsbury, Worcs.)	1.040 (28/12/36)	M. T. F.	0.66 0.27 6.5	(*a*) 1.030 (4/1/37) (*b*) 1.028 (20/4/37)	Poor quality and unpleasant in flavour.
Colman's Seedling. (Newton St. Cyres, Devon)	1.046 (24/11/36)	M. T. F.	0.61 0.16 4.2	(*a*) 1.030 (15/12/36) (*b*) 1.029 (20/4/37)	Quite a fair quality cider but rather lacking in body.
Crimson King. (Ilminster, Som.)	1.049 (13/11/36)	M. T. F.	0.55 0.13 7.0	(*a*) 1.030 (2/12/36) (*b*) 1.028 (20/4/37)	A pleasant cider although not very full.
Crimson King. (Burghill, Hereford)	1.040 (9/12/36)	M. T. F.	0.44 0.11 5.5.	(*a*) 1.030 (21/12/36) (*b*) 1.026 (20/4/37)	Very thin flavoured cider.
Dry Close Pippin. (S. Petherton, Som.)	1.053 (13/11/36)	M. T. F.	0.66 0.28 5.5	(*a*) 1.031 (16/12/36) (*b*) 1.030 (20/4/37)	Full in flavour but spoilt by poor tannin character.
Dymock Red. (Dymock, Glos.)	1.048 (10/11/36)	M. T. F.	0.61 0.21 4.0	(*a*) 1.031 (11/12/36) (*b*) 1.031 (20/4/37)	Below its usual standard. Not particularly clean and fresh in flavour.
Gloucester. (Shapwick, Som.)	1.037 (21/12/36)	M. T. F.	0.45 0.13 4.4	(*a*) 1.030 (28/12/36) (*b*) 1.028 (20/4/37)	Not pleasant in flavour and without character.
Gloucester Neverblight. (Westbury-on-Trym, Glos.)	1.038 (28/12/36)	M. T. F.	0.59 0.12 6.0	(*a*) 1.030 (7/1/37) (*b*) 1.027 (20/4/37)	Very thin and watery in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 2B.—Varieties of medium acidity—*continued.*				
Hollow Core. (Crediton, Devon)	1.049 (26/11/36)	M. 0.60 T. 0.19 F. 4.8	(*a*) 1.030 (22/12/36) (*b*) 1.029 (20/4/37)	A pleasant fruity cider but the acidity was a little too pronounced.
Kempley Red. (Byford, Hereford)	1.044 (21/12/36)	M. 0.44 T. 0.15 F. 5.0	(*a*) 1.028 (28/12/36) (*b*) 1.026 (20/4/37)	A fairly good medium sharp cider. Not very full in flavour but very clean and attractive.
Langworthy. (Taunton, Som.)	1.039 (18/11/36)	M. 0.40 T. 0.08 F. 4.2	(*a*) 1.030 (4/12/36) (*b*) 1.030 (20/4/37)	A high quality cider with a very attractive soft fruity flavour and good aroma.
Langworthy. (Newton St Cyres, Devon)	1.044 (24/11/36)	M. 0.54 T. 0.13 F. 3.2	(*a*) 1.030 (22/12/36) (*b*) 1.030 (20/4/37)	Not so fruity as the previous sample and rather too sharp as a drink unblended.
Langworthy. (Crediton, Devon)	1.042 (26/11/36)	M. 0.46 T. 0.13 F. 2.5	(*a*) 1.030 (1/1/37) (*b*) 1.030 (20/4/37)	A very good cider. Similar to the last but one sample, but not so soft in flavour.
Neverblight. (Shapwick, Som.)	1.046 (28/10/36)	M. 0.60 T. 0.16 F. 4.5	(*a*) 1.030 (19/11/36) (*b*) 1.027 (20/4/37)	Quite pleasant but not very full, and it was rather acid for the class.
Overton Red. (Tirley, Glos.)	1.051 (18/11/36)	M. 0.41 T. 0.07 F. 5.2	(*a*) 1.030 (15/12/36) (*b*) 1.029 (20/4/37)	A fairly good cider with a pleasing flavour. Worthy of further trial.
Painted Lady (Westbury-on-Trym, Glos.)	1.046 (10/11/36)	M. 0.68 T. 0.14 F. 3.7	(*a*) 1.030 (18/12/36) (*b*) 1.028 (20/4/37)	Pleasant sharp cider but too acid for the class. Very clean in flavour.

CLASS 2B.—Varieties of medium acidity—*continued.*

Peggies. (Bushley, Worcs.)	1.049 (10/11/36)	M. T. F.	0.50 0.17 3.7	(*a*) 1.030 (2/1/37) (*b*) 1.030 (20/4/37)	A very pleasant cider of good quality. It had an attractive aroma.
Price's Kernel. (Bushley, Worcs.)	1.041 (13/11/36)	M. T. F.	0.55 0.16 4.0	(*a*) 1.030 (7/12/36) (*b*) 1.028 (20/4/37)	Not very good, lacking fresh clean flavour.
Red Cluster. (South Petherton, Som.)	1.042 (26/10/36)	M. T. F.	0.63 0.10 3.0	(*a*) 1.030 (17/11/36) (*b*) 1.029 (20/4/37)	Very thin and poor in flavour. No character.
Red Foxwhelp. (Byford, Hereford)	1.040 (26/10/36)	M. T. F.	0.70 0.20 4.5	(*a*) 1.030 (7/11/36) (*b*) 1.029 (20/4/37)	Rather poor quality.
Rockfield Cowarne. (Monmouth, Mon.)	1.045 (23/12/36)	M. T. F.	0.52 0.16 2.0	(*a*) 1.030 (2/2/37) (*b*) 1.030 (20/4/37)	A fair quality cider with a pleasant fruity flavour.
Skyrme's Kernel. (Hardwicke, Glos.)	1.047 (9/12/36)	M. T. F.	0.51 0.13 3.4	(*a*) 1.030 (11/1/37) (*b*) 1.030 (20/4/37)	Fairly good cider and rich in flavour.
Stoke Red. (Rodney Stoke, Som.)	1.046 (17/11/36)	M. T. F.	0.58 0.27 2.5	(*a*) 1.031 (2/1/37) (*b*) 1.031 (20/4/37)	Not up to standard. Rather thin in character and the acidity was too pronounced.
Streaky Kernel. (Monmouth, Mon.)	1.045 (12/11/36)	M. T. F.	0.69 0.13 5.0	(*a*) 1.030 (29/12/36) (*b*) 1.030 (20/4/37)	Poor quality. Thin and raw in flavour.
Toogood Bitter. (Wedmore, Som.)	1.040 (28/12/36)	M. T. F.	0.55 0.24 7.3	(*a*) 1.030 (2/1/37) (*b*) 1.028 (20/4/37)	Not a pleasant cider.
Toogood Bitter. (Cheddar, Som.)	1.043 (14/12/36)	M. T. F.	0.73 0.24 3.5	(*a*) 1.030 (24/12/36) (*b*) 1.030 (20/4/37)	Very pronounced in acid flavour. Not very pleasant.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
SWEET VARIETIES. CLASS 3.				
Dent's Red. (Tarrington, Hereford)	1.040 (25/11/36)	M. 0.22 T. 0.15 F. 3.8	(*a*) 1.027 (5/12/36) (*b*) 1.027 (20/4/37)	Quite pleasant but very light in character.
Dunkerton Sweet. (Dunkerton, Som.)	1.043 (18/11/36)	M. 0.37 T. 0.09 F. 7.2	(*a*) 1.025 (5/12/36) (*b*) 1.024 (20/4/37)	Very poor, flavourless cider.
Ecarlatine. (Hardwicke, Glos.)	1.047 (6/11/36)	M. 0.15 T. 0.16 F. 5.7	(*a*) 1.025 (17/12/36) (*b*) 1.025 (20/4/37)	A good cider although not very full. It had a very good aroma.
Eggleton Styre. (Burghill, Hereford)	1.050 (25/11/36)	M. 0.23 T. 0.11 F. 5.6	(*a*) 1.025 (14/12/36) (*b*) 1.025 (20/4/37)	Fairly good cider but not very full flavour.
Eggleton Styre. (Byford, Hereford)	1.056 (25/11/36)	M. 0.25 T. 0.12 F. 5.6	(*a*) 1.025 (21/12/36) (*b*) 1.025 (20/4/37)	Fuller in flavour and very pleasant with a fair amount of character.
Eggleton Styre. (Barton St. David, Som.)	1.058 (25/11/36)	M. 0.26 T. 0.12 F. 5.0	(*a*) 1.025 (29/12/36) (*b*) 1.024 (20/4/37)	A very good " sweet " cider with a fine fruity flavour and more character than the previous entries of the variety.
Georges. (Wookey, Som.)	1.043 (23/12/36)	M. 0.21 T. 0.15 F. 3.8	(*a*) 1.025 (23/1/37) (*b*) 1.025 (20/4/37)	Lacking in character.
Honeystring. (Charlton Mackrell, Som.)	1.044 (4/11/36)	M. 0.28 T. 0.10 F. 7.0	(*a*) 1.025 (18/11/36) (*b*) 1.023 (20/4/37)	Rather poor quality ; very insipid.

CLASS 3.—SWEET VARIETIES—*continued.*

Killerton Sweet. (Pinhoe, Devon)	1.050 (26/11/36)	M. T. F.	0.23 0.14 5.8	(*a*) 1.025 (21/12/36) (*b*) 1.024 (20/4/37)	Quite a pleasant cider but not outstanding in any way.
Lewis' Sweet. (Raglan, Mon.)	1.041 (9/12/36)	M. T. F.	0.16 0.13 7.0	(*a*) 1.025 (17/12/36) (*b*) 1.023 (20/4/37)	Only fair ; lacking fullness of flavour
Northwood. (Tedburn St. Mary, Devon)	1.044 (14/12/36)	M T. F.	0.37 0.17 4.5	(*a*) 1.025 (28/12/36) (*b*) 1.024 (20/4/37)	Rather poor quality.
Northwood. (Newton St. Cyres, Devon)	1.044 (21/12/36)	M. T. F.	0.22 0.17 4.0	(*a*) 1.025 (5/1/37) (*b*) 1.025 (20/4/37)	Better than previous sample but only fair in quality.
Prescoed. (Usk, Mon.)	1.037 (23/12/36)	M. T. F.	0.19 0.14 3.3	(*a*) 1.025 (7/1/37) (*b*) 1.025 (20/4/37)	Very thin and watery.
Red Worthy. (South Petherton, Som.)	1.043 (12/11/36)	M. T. F.	0.27 0.15 6.2	(*a*) 1.025 (2/12/36) (*b*) 1.024 (20/4/37)	Very poor in quality, with a "woody" flavour.
Red Worthy. (East Lambrook, Som.)	1.048 (13/11/36)	M. T. F.	0.23 0.16 4.2	(*a*) 1.025 (28/12/36) (*b*) 1.024 (20/4/37)	Similar to the previous sample.
Shapwick Sweet. (Shapwick. Som.)	1.044 (4/11/36)	M. T. F.	0.23 0.13 4.7	(*a*) 1.025 (9/12/36) (*b*) 1.024 (20/4/37)	A pleasant cider but rather light in character.
Sheep's Nose. (Taunton, Som.)	1.039 (26/11/36)	M. T. F.	0.24 0.15 5.0	(*a*) 1.025 (11/12/36) (*b*) 1.024 (20/4/37)	Not unpleasant but lacking in flavour.
Slack-ma-Girdle. (Crediton, Devon)	1.045 (26/11/36)	M. T. F.	0.21 0.14 4.0	(*a*) 1.025 (30/12/36) (*b*) 1.024 (20/4/37)	A very clean, pleasing-flavoured cider but not very full.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 3.—SWEET VARIETIES—*continued.*				
Slack-ma-Girdle. (Newton St. Cyres, Devon)	1.045 (9/12/36)	M. 0.20 T. 0.14 F. 3.0	(*a*) 1.025 (13/1/37) (*b*) 1.024 (20/4/37)	Fair quality but not so pleasant as the previous sample.
Slack-ma-Girdle. (Shapwick, Som.)	1.043 (23/12/36)	M. 0.18 T. 0.10 F. 2.8	(*a*) 1.025 (11/2/37) (*b*) 1.025 (20/4/37)	Rather thin in flavour; lacking in character.
Sugar Sweet. (Shapwick, Som.)	1.042 (10/11/36)	M. 0.34 T. 0.09 F. 5.7	(*a*) 1.025 (5/12/36) (*b*) 1.024 (20/4/37)	A pleasant cider with a rather outstanding apple flavour.
Sweet Alford. (Woodbury, Devon)	1.045 (13/11/36)	M. 0.24 T. 0.14 F. 5.5	(*a*) 1.025 (18/12/36) (*b*) 1.025 (20/4/37)	A good flavoured cider and soft in character.
Sweet Alford. (Frampton Cotterell, Glos.)	1.050 (13/11/36)	M. 0.29 T. 0.14 F. 7.0	(*a*) 1.025 (10/12/36) (*b*) 1.024 (20/4/37)	Good quality cider with a fair amount of character.
Sweet Alford. (Llangattock Lingoed, Mon.)	1.051 (13/11/36)	M. 0.25 T. 0.14 F. 5.7	(*a*) 1.025 (5/1/37) (*b*) 1.023 (20/4/37)	Pleasant but rather thin in flavour.
Sweet Alford. (Hardwicke, Glos.)	1.047 (17/11/36)	M. 0.26 T. 0.13 F. 6.7	(*a*) 1.025 (11/12/36) (*b*) 1.025 (20/4/37)	Very fair cider; more character than in previous sample.
Sweet Alford. (Newton St. Cyres, Devon)	1.050 (17/11/36)	M. 0.23 T. 0.15 F. 4.2	(*a*) 1.025 (15/1/37) (*b*) 1.024 (20/4/37)	Pleasant cider, but it was lacking in character.

CLASS 3.—SWEET VARIETIES—*continued.*

Sweet Alford. (Berkeley, Glos.)	1.051 (17/11/36)	M. 0.25 T. 0.14 F. 4.3	(*a*) 1.025 (1/1/37) (*b*) 1.024 (20/4/37)	A very attractive cider, with a very pleasant, soft, neutral flavour.
Sweet Alford. (Crediton, Devon)	1.038 (26/11/36)	M. 0.24 T. 0.15 F. 4.3	(*a*) 1.025 (3/12/36) (*b*) 1.024 (20/4/37)	Quite pleasant but a little thin in flavour.
Sweet Cluster. (Cullompton, Devon)	1.048 (25/11/36)	M. 0.22 T. 0.14 F. 4.8	(*a*) 1.025 (21/12/36) (*b*) 1.023 (20/4/37)	Only fair; rather thin and insipid in flavour.
Taylor. (East Lambrook, Som.)	1.052 (24/11/36)	M. 0.29 T. 0.16 F. 3.2	(*a*) 1.025 (16/1/37) (*b*) 1.024 (20/4/37)	A fine quality cider, rich in apple flavour. It was full bodied yet soft and very pleasing.
Thomas Hunt. (North Cadbury, Som.)	1.047 (26/11/36)	M. 0.19 T. 0.13 F. 6.0	(*a*) 1.025 (9/12/36) (*b*) 1.022 (20/4/37)	Lacking in flavour and character.
Winslade's Jersey. (Low Ham, Som.)	1.044 (28/12/36)	M. 0.20 T. 0.13 F. 3.3	(*a*) 1.025 (23/1/37) (*b*) 1.025 (20/4/37)	Rather peculiar flavoured; not very pleasant.
Woodbine. (Kittisford, Som.)	1.054 (8/12/36)	M. 0.29 T. 0.17 F. 3.6	(*a*) 1.025 (26/12/36) (*b*) 1.024 (20/4/37)	Fair, but not up to usual standard.
Woodbine. (Shapwick, Som.)	1.048 (9/12/36)	M. 0.25 T. 0.13 F. 7.0	(*a*) 1.025 (26/12/36) (*b*) 1.024 (20/4/37)	A very pleasant cider but not very full.
Woodbine. (Taunton, Som.)	1.049 (14/12/36)	M. 0.38 T. 0.16 F. 2.3	(*a*) 1.025 (6/1/37) (*b*) 1.023 (20/4/37)	Fairly good quality but rather too acid for a "sweet" cider.
Woodbine. (Ilminster, Som.)	1.050 (23/12/36)	M. 0.23 T. 0.13 F. 5.4	(*a*) 1.025 (13/1/37) (*b*) 1.025 (20/4/37)	Fairly good but rather thin.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
BITTERSWEET VARIETIES.				
CLASS 4A.—MILD BITTERSWEETS				
Ashton No. 32. (Burghill, Hereford)	1.043 (28/12/36)	M. 0.20 T. 0.21 F. 3.5	(*a*) 1.026 (21/1/37) (*b*) 1.026 (20/4/37)	An interesting variety, worthy of further trial. It had a very pleasant fruity flavour.
Broom Apple. (Raglan, Mon.)	1.047 (24/11/36)	M. 0.33 T. 0.19 F. 3.5	(*a*) 1.025 (19/12/36) (*b*) 1.025 (20/4/37)	Rather poorer in quality; lacking freshness of flavour.
Brown Jersey. (Dunkerton, Som.)	1.044 (18/11/36)	M. 0.20 T. 0.25 F. 2.6	(*a*) 1.026 (7/1/37) (*b*) 1.026 (20/4/37)	Inclined to be thin in flavour.
Buskin. (North Cadbury, Som.)	1.046 (23/12/36)	M. 0.29 T. 0.17 F. 3.8	(*a*) 1.025 (18/1/37) (*b*) 1.025 (20/4/37)	Pleasant but not full flavoured.
Cadbury. (North Cadbury, Som.)	1.041 (17/11/36)	M. 0.25 T. 0.22 F. 2.8	(*a*) 1.025 (2/1/37) (*b*) 1.025 (20/4/37)	Not clean in flavour and without character.
Cummy Norman. (Hardwicke, Glos.)	1.055 (6/11/36)	M. 0.21 T. 0.20 F. 7.7	(*a*) 1.025 (25/11/36) (*b*) 1.024 (20/4/37)	Full flavoured cider with a very attractive mild tannin character.
Cummy Norman. (Llantilio Crossenny, Mon.)	1.051 (13/11/36)	M. 0.24 T. 0.20 F. 9.0	(*a*) 1.025 (2/12/36) (*b*) 1.022 (20/4/37)	Rather hard in flavour.
Cummy Norman. (Norton Canon, Hereford)	1.052 (24/11/36)	M. 0.24 T. 0.23 F. 5.0	(*a*) 1.025 (22/12/36) (*b*) 1.025 (20/4/37)	A good mild bittersweet with good tannin flavour.

CLASS 4A.—BITTERSWEET VARIETIES—*continued.*

Cummy Norman. (Burghill, Hereford)	1.051 (25/11/36)	M. T. F.	0.34 0.21 5.8	(*a*) 1.025 (17/12/36) (*b*) 1.024 (20/4/37)	Fair quality, not outstanding.
Cummy Norman. (Barton St. David, Som.)	1.050 (9/12/36)	M. T. F.	0.15 0.17 3.0	(*a*) 1.025 (8/1/37) (*b*) 1.024 (20/4/37)	Very high quality cider with fine bitter character and a very attractive aroma.
George James. (North Cadbury, Som.)	1.051 (26/11/36)	M. T. F.	0.22 0.23 5.3	(*a*) 1.026 (17/12/36) (*b*) 1.026 (20/4/37)	Lacking in freshness of flavour.
Hangdown. (Cheddar, Som.)	1.045 (26/10/36)	M. T. F.	0.21 0.21 3.0	(*a*) 1.025 (18/12/36) (*b*) 1.025 (20/4/37)	Thin, poor quality cider.
Hangdown. (Shapwick, Som.)	1.049 (26/10/36)	M. T. F.	0.25 0.20 4.6	(*a*) 1.026 (11/2/36) (*b*) 1.026 (20/4/37)	Good, full-flavoured, pleasant cider.
Henry's Bitter. (Shapwick, Som.)	1.051 (14/12/36)	M. T. F.	0.18 0.23 5.0	(*a*) 1.025 (26/12/36) (*b*) 1.025 (20/4/37)	A fine cider with a particularly attractive tannin flavour.
Large Hangdown. (Chagford, Devon)	1.040 (6/11/36)	M. T. F.	0.22 0.17 5.7	(*a*) 1.025 (28/11/36) (*b*) 1.025 (20/4/37)	Very poor and thin in flavour.
Perthyre. (Raglan, Mon.)	1.043 (24/11/36)	M. T. F.	0.25 0.15 2.8	(*a*) 1.025 (18/12/36) (*b*) 1.024 (20/4/37)	Poor in flavour and lacking character
Perthyre. (Norton Canon, Hereford)	1.045 (25/11/36)	M. T. F.	0.22 0.23 5.5	(*a*) 1.025 (17/12/36) (*b*) 1.024 (20/4/37)	Very little character and not very pleasing.
Perthyre. (Dingestow, Mon.)	1.050 (9/12/36)	M. T. F.	0.21 0.19 3.8	(*a*) 1.025 (11/1/37) (*b*) 1.021 (20/4/37)	Not up to standard from this district, rather thin in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 4A.—BITTERSWEET VARIETIES—*continued*.				
Perthyre. (Monmouth, Mon.)	1.040 (23/12/36)	M. 0.18 T. 0.14 F. 3.0	(*a*) 1.025 (7/1/37) (*b*) 1.024 (20/4/37)	Only fair in quality.
Port Wine. (Wookey, Som.)	1.048 (21/12/36)	M. 0.23 T. 0.21 F. 4.5	(*a*) 1.025 (5/1/37) (*b*) 1.025 (20/4/37)	Very good cider with a fine tannin character.
Royal George. (Easton-in-Gordano, Som.)	1.051 (17/10/36)	M. 0.41 T. 0.23 F. 7.0	(*a*) 1.025 (12/11/36) (*b*) 1.023 (20/4/37)	Not outstanding.
Royal Wilding. (Hardwicke, Glos.)	1.053 (10/11/36)	M. 0.25 T. 0.20 F. 4.1	(*a*) 1.025 (22/12/36) (*b*) 1.023 (20/4/37)	A pleasant cider but not very full in flavour.
Royal Wilding. (Holmer, Hereford)	1.051 (12/11/36)	M. 0.27 T. 0.23 F. 4.0	(*a*) 1.025 (29/12/36) (*b*) 1.024 (20/4/37)	Similar to previous sample.
Sercombe's Natural. (Tedburn St. Mary, Devon)	1.043 (17/11/36)	M. 0.18 T. 0.21 F. 3.0	(*a*) 1.025 (18/1/37) (*b*) 1.024 (20/4/37)	A very good, rich, fruity cider and worthy of further investigation. It retained a fresh flavour after prolonged storage.
Sparkler. (Baltonsborough, Som.)	1.048 (9/12/36)	M. 0.16 T. 0.23 F. 2.8	(*a*) 1.025 (26/1/37) (*b*) 1.024 (20/4/37)	Rather poor quality. It developed "sickness" at an early date.
Spotted Dick. (Woodbury, Devon)	1.047 (14/12/36)	M. 0.24 T. 0.17 F. 2.6	(*a*) 1.025 (28/12/36) (*b*) 1.025 (20/4/37)	A pleasant cider; rich in flavour and with a good aroma.

CLASS 4B.—MEDIUM BITTERSWEETS.

Bulmer's Norman. (Tarrington, Hereford)	1.051 (4/11/36)	M. 0.24 T. 0.32 F. 6.7	(*a*) 1.025 (30/11/36) (*b*) 1.023 (20/4/37)	A useful bittersweet for blending purposes. Although not very full in flavour it had a good clean tannin character.
Dabinett. (East Lambrook, Som.)	1.050 (21/12/36)	M. 0.19 T. 0.26 F. 4.3	(*a*) 1.025 (25/1/37) (*b*) 1.024 (20/4/37)	A good quality cider, full and pleasant with a fine apple flavour.
Dabinett. (Low Ham, Som.)	1.046 (28/12/36)	M. 0.27 T. 0.29 F. 3.0	(*a*) 1.025 (16/1/37) (*b*) 1.024 (20/4/37)	A good cider but not up to the quality of the previous sample.
Dove. (Shapwick, Som.)	1.048 (28/10/36)	M. 0.37 T. 0.24 F. 5.2	(*a*) 1.025 (28/11/36) (*b*) 1.025 (20/4/37)	Only fair in quality.
Dove. (Somerton, Som.)	1.045 (25/11/36)	M. 0.23 T. 0.22 F. 4.3	(*a*) 1.025 (18/12/36) (*b*) 1.022 (20/4/37)	A pleasant cider but rather too mild for the class.
Dove. (Baltonsborough, Som.)	1.040 (21/8/36)	M. 0.29 T. 0.26 F. 4.0	(*a*) 1.025 (1/1/37) (*b*) 1.024 (20/4/37)	Pleasant but not very full.
Dunkerton Bitter. (Dunkerton, Som.)	1.045 (14/12/36)	M. 0.28 T. 0.28 F. 6.8	(*a*) 1.020 (21/12/36) (*b*) 1.016 (20)4)37)	Very poor quality.
Etsome Bitter. (Somerton, Som.)	1.052 (9/12/36)	M. 0.18 T. 0.28 F. 6.0	(*a*) 1.025 (30/12/36) (*b*) 1.022 (20/4/37)	Spoilt by an unpleasant tannin flavour.
Fillbarrel. (North Cadbury, Som.)	1.050 (26/11/36)	M. 0.21 T. 0.27 F. 5.3	(*a*) 1.025 (21/12/36) (*b*) 1.023 (20/4/37)	A good cider with a very clean flavour; useful for blending.
Hale's Jersey. (Rodney Stoke, Som.)	1.049 (23/12/36)	M. 0.18 T. 0.32 F. 3.4	(*a*) 1.025 (19/2/37) (*b*) 1.023 (20/4/37)	A fine full-flavoured cider with a very attractive tannin character.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (a) Time of Filtering. (b) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 4B.—MEDIUM BITTERSWEETS—*continued.*				
Harry Master's Jersey. (North Cadbury, Som.)	1.053 (14/12/36)	M. 0.22 T. 0.25 F. 2.7	(*a*) 1.025 (31/12/36) (*b*) 1.024 (20/4/37)	An excellent flavoured cider; very fruity with a fine bitter quality.
Norton Bitter. (Baltonsborough, Som.)	1.056 (9/12/36)	M. 0.15 T. 0.26 F. 5.0	(*a*) 1.025 (8/1/37) (*b*) 1.024 (20/4/37)	Fair quality cider but not outstanding.
Pinney's Jersey. (Somerton, Som.)	1.052 (29/10/36)	M. 0.30 T. 0.24 F. 2.7	(*a*) 1.025 (5/2/37) (*b*) 1.024 (20/4/37)	A very good blending cider; rich in flavour and dark in colour.
Redstreak Bittersweet. (Corse Lawn, Glos.)	1.049 (4/11/36)	M. 0.25 T. 0.23 F. 8.0	(*a*) 1.025 (20/11/36) (*b*) 1.021 (20/4/37)	Thin in flavour but quite pleasant.
White Norman. (Tarrington, Hereford)	1.048 (4/11/36)	M. 0.32 T. 0.24 F. 4.4	(*a*) 1.025 (29/12/36) (*b*) 1.024 (20/4/37)	A very pleasing cider, clean and fresh in flavour.
Yarlington Mill Jersey. (Baltonsborough, Som.)	1.045 (24/11/36)	M. 0.21 T. 0.26 F. 2.2	(*a*) 1.025 (26/1/36) (*b*) 1.025 (20/4/37)	Not very clean in flavour.
Yarlington Mill Jersey. (North Cadbury, Som.)	1.042 (23/12/36)	M 0.19 T. 0.29 F. 3.0	(*a*) 1.025 (5/2/37) (*b*) 1.023 (20/4/37)	Very good cider with a fine bitter flavour and a good apple aroma.

CLASS 4c.—Full Bittersweets.

Bedan des Partes. (Burghill, Hereford)	1.049 (28/12/36)	M. 0.23 T. 0.29 F. 6.0	(*a*) 1.025 (25/1/37) (*b*) 1.024 (20/4/37)	Rather poor quality.
Bourne's Bitter. (Burghill, Hereford)	1.046 (28/12/36)	M. 0.20 T. 0.34 F. 4.2	(*a*) 1.025 (7/1/37) (*b*) 1.024 (20/4/37)	Fair quality but the tannin was hard.
Bramtôt. (Byford, Hereford)	1.060 (4/11/36)	M. 0.31 T. 0.36 F. 7.8	(*a*) 1.025 (1/12/36) (*b*) 1.024 (20/4/37)	A coarse flavoured cider.
Chisel Jersey. (North Cadbury, Som.)	1.042 (21/12/36)	M. 0.25 T. 0.32 F. 3.3	(*a*) 1.025 (31/12/36) (*b*) 1.025 (20/4/37)	Good quality cider ; a good blender.
Knotted Kernel. (Llantilio Crossenny, Mon.)	1.056 (7/12/36)	M. 0.27 T. 0.29 F. 4.2	(*a*) 1.025 (28/12/36) (*b*) 1.024 (20/4/37)	Very good with a very pleasant bitter flavour.
Knotted Kernel. (Norton Canon, Hereford)	1.055 (7/12/36)	M. 0.18 T. 0.30 F. 3.8	(*a*) 1.025 (27/2/37) (*b*) 1.025 (20/4/37)	An excellent cider with a very attractive, soft rich tannin character.
Knotted Kernel. (Norton Canon, Hereford)	1.053 (7/12/36)	M. 0.18 T. 0.26 F. 6.3	(*a*) 1.025 (30/12/36) (*b*) 1.025 (20/4/37)	Similar to the previous sample, but not quite so full-flavoured.
Knotted Kernel. (Byford, Hereford)	1.050 (7/12/36)	M. 0.20 T. 0.27 F. 4.5	(*a*) 1.025 (21/12/36) (*b*) 1.022 (20/4/37)	Also very good but it might be fuller.
Medaille d'Or. (Byford, Hereford)	1.045 (4/11/36)	M. 0.32 T. 0.44 F. 5.7	(*a*) 1.025 (30/11/36) (*b*) 1.023 (20/4/37)	Fairly typical of the variety ; good quality although very bitter.
Mill's Bitter. (Stourport, Worcs.)	1.042 (28/12/36)	M. 0.33 T. 0.34 F. 4.5	(*a*) 1.025 (5/1/37) (*b*) 1.024 (20/4/37)	Poor quality.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Ciders.
CLASS 4c.—Full Bittersweets—*continued*.				
River Apple B. (Cheddar, Som.)	1.053 (28/12/36)	M. 0.26 T. 0.39 F. 4.7	(*a*) 1.025 (14/1/37) (*b*) 1.024 (20/4/37)	A cider of outstanding quality; very full flavoured with an attractive tannin character.
Red Jersey. (Shapwick, Som.)	1.048 (21/12/36)	M. 0.20 T. 0.30 F. 2.9	(*a*) 1.025 (13/1/37) (*b*) 1.023 (20/4/37)	Good quality cider, although it might have been fuller it was very pleasant.
Strawberry Norman. (Hardwicke, Glos.)	1.048 (6/11/36)	M. 0.24 T. 0.30 F. 7.0	(*a*) 1.026 (28/11/36) (*b*) 1.026 (20/4/37)	Rather thin and coarse in flavour.
Strawberry Norman. (Burghill, Hereford)	1.052 (12/11/36)	M. 0.32 T. 0.42 F. 4.2	(*a*) 1.025 (4/1/37) (*b*) 1.023 (20/4/37)	A little fuller in flavour than the previous sample, but not very attractive.
Strawberry Norman. (Barton St. David, Som.)	1.050 (12/11/36)	M. 0.28 T. 0.37 F. 4.8	(*a*) 1.025 (18/12/36) (*b*) 1.024 (20/4/37)	Fair quality cider. Much more flavour than the previous sample.
Strawberry Norman. (Dymock, Glos.)	1.053 (12/11/36)	M. 0.37 T. 0.36 F. 6.7	(*a*) 1.025 (17/12/36) (*b*) 1.024 (20/4/37)	Similar to previous sample.
Strawberry Norman. (Vowchurch, Hereford)	1.052 (13/11/36)	M. 0.40 T. 0.42 F. 5.5	(*a*) 1.026 (22/12/36) (*b*) 1.026 (20/4/37)	Not attractive; tannin character very harsh.
Strawberry Norman. (Frampton Cotterell, Glos.)	1.051 (13/11/36)	M. 0.33 T. 0.39 F. 6.0	(*a*) 1.025 (8/12/36) (*b*) 1.025 (20/4/37)	Not outstanding.

CLASS 4c.—FULL BITTERSWEETS—*continued.*				
Strawberry Norman. (Burghill, Hereford)	1.049 (17/11/36)	M. 0.31 T. 0.39 F. 8.3	(*a*) 1.025 (5/12/36) (*b*) 1.020 (20/4/37)	Rather poor; lacking in character and with a coarse tannin flavour.
Strawberry Norman. (Norton Canon, Hereford)	1.049 (25/11/36)	M. 0.30 T. 0.30 F. 6.5	(*a*) 1.025 (14/12/36) (*b*) 1.025 (20/4/37)	Quite the best sample of this variety; a very fair cider.
Totney Jersey. (Wedmore, Som.)	1.051 (9/12/36)	M. 0.20 T. 0.41 F. 3.8	(*a*) 1.025 (20/1/37) (*b*) 1.023 (20/4/37)	Poor quality cider with a very coarse, unpleasant, bitter flavour.
Wale's Jersey. (Pitminster, Som.)	1.049 (12/11/36)	M. 0.31 T. 0.30 F. 5.4	(*a*) 1.025 (12/12/36) (*b*) 1.024 (20/4/37)	Very pleasant cider with a clean fruity flavour. Worthy of further trial.
White Styre. (Stonehouse, Glos.)	1.050 (14/12/36)	M. 0.35 T. 0.38 F. 4.8	(*a*) 1.027 (4/1/37) (*b*) 1.027 (20/4/37)	Rather too acid but very pleasant flavour and aroma.
CLASS 5.—PERRIES				Notes on Perries.
Barland. (Byford, Hereford)	1.039 (30/9/36)	M. 0.30 T. 0.08 F. 8.5	(*a*) 1.030 (8/10/36) (*b*) 1.020 (20/4/37)	Thin and poor in flavour with no character.
Barnam. (Monmouth, Mon.)	1.044 (12/10/36)	M. 0.45 T. 0.07 F. 4.8	(*a*) 1.030 (28/10/36) (*b*) 1.029 (20/4/37)	Not very full in flavour but a pleasant drink.
Barnett. (Monmouth, Mon.)	1.047 (28/10/36)	M. 0.29 T. 0.10 F. 4.2	(*a*) 1.030 (28/11/36) (*b*) 1.029 (20/4/37)	Good quality perry, soft and delicate in flavour.
Blakeney Red. (Monmouth, Mon.)	1.040 (12/10/36)	M. 0.39 T. 0.11 F. 3.0	(*a*) 1.030 (11/11/36) (*b*) 1.028 (20/4/37)	Only fair quality.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Perries.
CLASS 5.—PERRIES—*continued.*				
Blakeney Red. (Dymock, Glos.)	1.047 (12/10/36)	M. 0.49 T. 0.19 F. 3.0	(*a*) 1.030 (2/1/37) (*b*) 1.030 (20/4/37)	Rather thin and too acid in flavour.
Blakeney Red. (Rockfield, Mon.)	1.049 (26/10/36)	M. 0.41 T. 0.09 F. 3.3	(*a*) 1.030 (28/11/36) (*b*) 1.030 (20/4/37)	A very attractive perry of the low astringency type. A delicate soft flavoured drink.
Blakeney Red. (Monmouth, Mon.)	1.046 (28/10/36)	M. 0.37 T. 0.08 F. 3.5	(*a*) 1.030 (27/11/36) (*b*) 1.029 (20/4/37)	Quite sound but rather thin in flavour.
Blakeney Red. (Chaceley, Glos.)	1.050 (4/11/36)	M. 0.48 T. 0.09 F. 4.5	(*a*) 1.030 (30/11/36) (*b*) 1.029 (20/4/37)	Fair quality but lacking character.
Blakeney Red. (Raglan, Mon.)	1.045 (4/11/36)	M. 0.48 T. 0.07 F. 5.2	(*a*) 1.030 (20/11/36) (*b*) 1.026 (20/4/37)	Similar to the previous sample.
Bomford's Pear. (Peopleton, Worcs.)	1.042 (12/10/36)	M. 0.42 T. 0.08 F. 8.5	(*a*) 1.030 (17/10/36) (*b*) 1.029 (20/4/37)	A pleasant drink but lacking in character and astringency.
Burcher's Pear. (Ashleworth, Glos.)	1.035 (8/12/36)	M. 0.38 T. 0.08 F. 5.0	(*a*) 1.030 (15/12/36) (*b*) 1.024 (20/4/37)	Rather poor quality.
Butt. (Tarrington, Hereford)	1.052 (10/11/36)	M. 0.54 T. 0.21 F. 3.0	(*a*) 1.030 (8/2/37) (*b*) 1.028 (20/4/37)	High quality sample of the astringent type; full with a good tannin flavour.

CLASS 5.—PERRIES—*continued.*				
Butt. (Stonehouse, Glos.)	1.051 (24/11/36)	M. 0.52 T. 0.29 F. 1.7	(*a*) 1.030 (1/3/37) (*b*) 1.028 (20/4/37)	Typical perry from this variety; not so full in flavour as the previous sample but it had a good astringent flavour.
Butt. (Ebley, Glos.)	1.049 (8/12/36)	M. 0.45 T. 0.28 F. 3.0	(*a*) 1.030 (28/12/36) (*b*) 1.027 (20/4/37)	Similar to the previous sample.
Butt. (Hardwicke, Glos.)	1.048 (8/12/36)	M. 0.48 T. 0.16 F. 3.0	(*a*) 1.030 (1/1/37) (*b*) 1.028 (20/4/37)	Similar to the previous sample.
Dandoes. (Hardwicke, Glos.)	1.040 (23/10/36)	M. 0.91 T. 0.14 F. 3.5	(*a*) 1.030 (29/10/36) (*b*) 1.024 (20/4/37)	Very poor perry with an extremely hard, acid flavour.
Holmer. (Holmer, Hereford)	1.067 (26/10/36)	M. 0.68 T. 0.14 F. 4.4	(*a*) 1.030 (7/1/37) (*b*) 1.030 (20/4/37)	Very heavy type of perry and lacking in freshness of flavour.
Huffcap. (Stonehouse, Glos.)	1.057 (6/11/36)	M. 0.52 T. 0.12 F. 7.2	(*a*) 1.030 (25/11/36) (*b*) 1.024 (20/4/37)	Fair but rather too "dry" in flavour.
Ludlow's Pear. (Westbury-on-Trym, Glos.)	1.044 (23/10/36)	M. 0.51 T. 0.13 F. 4.0	(*a*) 1.030 (16/11/36) (*b*) 1.028 (20/4/37)	A pleasant perry but not very full-flavoured.
Moorcroft. (Byford, Hereford)	1.048 (30/9/36)	M. 0.42 T. 0.12 F. 7.4	(*a*) 1.030 (17/10/36) (*b*) 1.030 (20/4/37)	A very attractive light, fruity drink.
Moorcroft. (Newent, Glos.)	1.054 (30/10/36)	M. 0.43 T. 0.15 F. 4.3	(*a*) 1.030 (18/11/36) (*b*) 1.027 (20/4/37)	Only moderate quality, rather hard in flavour.
Moorcroft. (Upton Snodsbury, Worcs.)	1.040 (12/10/36)	M. 0.46 T. 0.09 F. 3.2	(*a*) 1.030 (7/11/36) (*b*) 1.026 (20/4/37)	Quite attractive but not very full in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 20/37).	Notes on Perries.
CLASS 5.—PERRIES—*continued.*				
Oldfield. (Westhide, Hereford)	1.055 (10/11/36)	M. 0.62 T. 0.13 F. 4.7	(*a*) 1.030 (28/12/36) (*b*) 1.029 (20/4/37)	Far below the usual standard for this variety. Very raw and too acid in flavour.
Red Longdon. (Peopleton, Worcs.)	1.056 (12/10/36)	M. 0.55 T. 0.08 F. 4.8	(*a*) 1.030 (12/11/36) (*b*) 1.029 (20/4/37)	Pleasant but not outstanding in quality.
Taynton Squash. (Llangattock Lingoed, Mon.)	1.046 (16/10/36)	M. 0.40 T. 0.11 F. 4.0	(*a*) 1.030 (7/11/36) (*b*) 1.026 (20/4/37)	A high quality perry; rich and fruity in flavour.

NON-COMPETITIVE VARIETIES.

Variety and Grower.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Sampling. (April 20/37).	Notes on Ciders.
Argile Grise. (W. Wootton, Byford, Hereford)	1.048 (7/12/36)	M. 0.21 T. 0.24 F. 4.8	(*a*) 1.025 (2/1/37) (*b*) 1.023 (20/4/37)	A very useful bittersweet for blending purposes.
Italy Bittersweet. (G. A. Nott, Newnham Bridge, Worcs.)	1.048 (7/12/36)	M. 0.18 T. 0.26 F. 4.5	(*a*) 1.025 (6/1/37) (*b*) 1.023 (20/4/37)	Good quality cider, although not very full-bodied it was quite attractive.

COMPETITION CIDERS, 1936-37.

JUDGES AWARDS.

CLASS 1.—KINGSTON BLACK. (23 *Entries*).

First Prize	R. Williams, Hardwicke, Glos.
Second Prize	E. T. Bryant, Taunton, Som.
Third Prize	H. R. Scudamore, Llantilio Crossenny, Mon.
Reserve	Mental Hospital, Burghill, Hereford.
Very Highly Com'ded	W. P. Merrett, Arlingham, Glos.
Highly Commended	J. Cooke, Kittisford, Som.
,, ,,	Miss A. Badger, Upton Snodsbury, Worcs.
,, ,,	P. T. Prosser, Norton Canon, Hereford.
Commended	G. Date, Dunkerton, Bath, Som.

CLASS 2A.—SHARP VARIETIES. (21 *Entries*).

		Variety.
First Prize	H. R. Scudamore, Llantilio Crossenny, Mon.	Cap of Liberty.
Second Prize	T. G. Bullock, Easton-in-Gordano, Som.	Bastard Tom Putt.
Third Prize	C. Fawkes, Stonehouse, Glos.	White Thorn Pippin
Reserve	T. G. Bullock, Easton-in-Gordano, Som.	Hartisman.
Very Highly Com'ded	A. L. Thomas, Mon.	Frederick.
,, ,, ..	E. Wood, Hendre, Monmouth,Mon.	Frederick.
Commended	A. I. Morris, Llangattock Lingoed, Mon.	Frederick.

CLASS 2B.—MEDIUM SHARP VARIETIES. (28 *Entries*).

First Prize	E. T. Bryant, Taunton, Som.	Langworthy.
Second Prize	W. Hole, Wedmore, Som.	Black Jack.
Third Prize	A. Pope, Crediton, Devon	Langworthy.
Reserve	A. Pope, Crediton, Devon	Hollow Core.
Very Highly Com'ded	L. E. Guilding, Bushley, Worcs.	Peggies.
Highly Commended	R. Williams, Hardwicke, Glos.	Skyrme's Kernel.

CLASS 3.—SWEET VARIETIES. (36 *Entries*).

First Prize	W. Porter, South Petherton, Som.	Taylor.
Second Prize	A. Chamberlayne, Berkeley, Glos.	Sweet Alford.
Third Prize	J. P. Eley, Frampton Cotterell, Glos.	Sweet Alford.
Reserve	S. R. Plumley, Barton St. David, Som.	Eggleton, Styre.
Very Highly Com'ded	R. Williams, Hardwicke, Glos.	Ecarlatine.
.. ,, ,,	W. Wootton, Byford, Hereford	Eggleton Styre.
,, ,, ,,	S. B. Neill, Woodbury, Devon	Sweet Alford.
Higly Commended	Mental Hospital, Burghill, Hereford	Eggleton Styre.
,, ..	C. A. Jennings, Shapwick, Som.	Shapwick Sweet.
.. ,,	C. A. Jennings, Shapwick, Som.	Sugar Sweet.
.. ..	A. Pope, Crediton, Devon	Sweet Alford.
,, ,,	C. A. Jennings, Shapwick, Som.	Woodbine.

CLASS 4A.—MILD BITTERSWEET VARIETIES. (26 *Entries*).

First Prize	S. R. Plumley, Barton St. David	Cummy Norman.
Second Prize	C. A. Jennings, Shapwick, Som.	Henry's Bitter.
Third Prize	T. Gray, Tedburn St. Mary, Devon	Sercombe's Natural
Reserve	D. H. G. Brown, Wookey, Som.	Port Wine.
Very Highly Com'ded	C. A. Jennings, Shapwick, Som.	Hangdown.
Highly Commended	S. B. Neill, Woodbury, Devon	Spotted Dick.
Commended	F. & L. Edwards, Norton Canon, Hereford	Cummy Norman.

CLASS 4B.—MEDIUM BITTERSWEET VARIETIES. (17 *Entries*).

		Variety.
First Prize	S. H. Osborn, North Cadbury, Som.	Harry Masters' Jersey.
Second Prize	G. Hale, Rodney Stoke, Som.	Hale's Jersey.
Third Prize	R. W. Pretor Pinney, Somerton, Som.	Pinney's Jersey.
Reserve	W. Porter, South Petherton, Som.	Dabinett.
Very Highly Com'ded	C. W. Winslade, Low Ham, Som.	Dabinett.
,, ,, ,,	S. H. Osborn, North Cadbury, Som.	Yarlington Mill Jersey.
Highly Commended	M. R. Adams, Somerton, Som.	Dove.
,, ,,	H. C. Dent, Tarrington, Hereford	White Norman.
Commended	S. H. Osborn, North Cadbury, Som.	Fillbarrel.

CLASS 4C.—FULL BITTERSWEET VARIETIES. (23 *Entries*).

First Prize	G. E. Tyley, Cheddar, Som.	River Apple B.
Second Prize	F. & L. Edwards, Norton Canon, Hereford	Knotted Kernel.
Third Prize	P. T. Prosser, Norton Canon, Hereford	Knotted Kernel.
Reserve	F. & L. Edwards, Norton Canon, Hereford	Strawberry Norman
Very Highly Com'ded	S. H. Osborn, North Cadbury, Som.	Chisel Jersey.
,, ,, ..	F. H. Scudamore, Llantilio Crossenny, Mon.	Knotted Kernel.
,, ,, ,,	J. Wale, Pitminster, Som.	Wale's Jersey.
Highly Commended	W. Wootton, Byford, Hereford	Medaille d'Or.
,, ,,	C. A. Jennings, Shapwick, Som.	Red Jersey.
Commended	S. R. Plumley, Barton St. David, Som.	Strawberry Norman
..	C. Fawkes, Stonehouse, Glos.	White Styre.

CLASS 5.—PERRIES. (25 *Entries*).

First Prize	J. E. Bradley, Rockfield, Som.	Blakeney Red.
Second Prize	E. Wood, Hendre, Mon.	Barnet.
Third Prize	W. Wootton, Byford, Hereford	Moorcroft.
Reserve	A. I. Morris, Llangattock Lingoed, Mon.	Taynton Squash.
Very Highly Com'ded	J. F. Bomford, Peopleton, Worcs.	Bomford's Pear.
Highly Commended	C. Fawkes, Stonehouse, Glos.	Butt.
,, ,,	W. S. Robbins & Son, Ebley, Glos.	Butt.
,, ,,	R. Williams, Hardwicke, Glos.	Butt.
,, ,,	W. Ludlow, Westbury-on-Trym, Glos.	Ludlow's Pear.
,, ,,	P. E. Bomford, Upton Snodsbury, Worcs.	Moorcroft.

SPECIAL PRIZES.

Special Prizes awarded for the best SHARP, SWEET and BITTERSWEET Varieties which have not previously obtained a prize in these competitions :—

		Variety.
Sharp Variety	W. Hole, Wedmore, Som.	Black Jack.
Sweet Variety	W. Porter, South Petherton, Som.	Taylor.
Bittersweet Variety	G. Hale, Rodney Stoke, Som.	Hale's Jersey.

Special Prize awarded in Class 5, for the best Perry representing the astringent type :—

H. C. Dent, Tarrington, Hereford .. .. Butt.

THE CIDER COMPETITIONS SCHEME, 1936-1937.

A NEW FEATURE—AWARDS FOR FRUIT CONDITION.

By P. T. H. PICKFORD and G. T. SPINKS.

For the first time since these Annual Competitions were begun prizes have been awarded for Fruit Condition. In the past no specific awards were made for this feature, although notice was taken of the state of each entry of fruit as received at the Research Station. Great variability in the condition of individual consignments occurred and the quality and yield of the ciders made from the separate entries were influenced—in some cases very markedly—by the state of the fruit. To that extent competitors improved or lessened their chances of awards when the ciders came up for judgment, but no more direct stimulus to encourage care in the harvesting, storage and consignment of the fruit was offered to the grower. The Competitions Committee, when settling the details of the 1936-37 Competitions, decided that the time had arrived when more direct attention to this feature could be shown in the general interest of the cider industry through the medium of these annual competitions.

From the cider-maker's point of view the importance of the fruit reaching the factory in good condition can scarcely be overemphasised. The presence of substances such as leaves, grass or soil in a consignment of apples entails extra work in the ciderhouse, as this extraneous matter must be removed before milling the fruit, if the highest possible yield of juice and control of the quality of the cider are to be obtainable. Rotten fruit, by influencing the rate of fermentation of the juice and by introducing undesirable organisms, may affect the flavour, quality and keeping properties of the cider. Apples badly bruised or suffering from skin abrasions are equally undesirable, as they may rot before the bulk of the consignment is ready for milling. Fruit supplied as a specified variety should be true to name and not contain any admixture of other varieties: this is of special importance where named varieties are required for the production of standard blends or single-variety ciders.

In contrast to the remarkable advances in methods and general conditions of cidermaking during the present century, relatively little progress has been made in respect of the harvesting and care of the raw material. As one means of attracting attention to the importance of this phase of cider production and of ascertaining the degree of improvement practicable under existing conditions, the Institute Competition Scheme was extended as indicated above for the season 1936-37. A summarized account of the procedure in connection with this new feature and a brief review of the results and conclusions are appended.

Competition Procedure and Awards.

Each sample of fruit entered for the competition was examined as soon as possible after its receipt and was awarded marks according to the following scale of points :—

	Maximum points.
Purity of Variety	10
Freedom from Rotten Fruit	30
,, ,, Broken Skin	30
,, ,, Bruising	10
,, ,, Extraneous Matter	20
	100

Two hundred and seven separate samples of fruit were received and judged, 19 of these being perry pears and the remainder cider apples.

In awarding the prizes due consideration was given to the susceptibility to bruising of some varieties, to the greater difficulty of delivering pears in good condition and to the fact that some fruit travelled long distances by rail while other consignments had only short direct journeys by road. No competitor was penalized, therefore, on account of the sort or variety of fruit entered, or owing to the method or distance of transport.

The prize for the consignment of fruit received in the best condition was awarded to R. Williams, Hardwicke, Glos. Additional prizes for fruit received in good condition were awarded to :—

J. P. Eley, Frampton Cotterell, Glos.
C. A. Jennings, Shapwick, Somerset.
W. Porter, East Lambrook, Somerset.
C. W. Winslade, Lower Ham, Somerset.

Review of Results.

There are many points of significant interest in the list of marks awarded and some of these are dealt with below, firstly under the separate categories in which marks were lost, and then more generally.

Purity of Variety.

If more than 10 per cent. of impurity was found the entry was disqualified from the competition. Eight entries were excluded for this reason and are not included in the following statistics.

The remaining 199 samples were on the whole very true to name, 185 receiving full marks and the average mark obtained being 9.8 out of a possible 10. Only 14 of the entries contained any mixture of varieties. In six cases only one mark was lost, but four entries lost 5 marks each and in one case 9 marks were deducted, as the impurity amounted to nearly 10 per cent.

Rotten Fruit.

The average mark obtained in this section was 26.4 out of a possible 30. Thirty-seven entries earned full marks, being entirely free from rotten fruit, while in 121 other cases 25 marks or more were awarded. The marks were below 20 for 14 entries and one very bad sample received only 10 marks. Three of the worst entries were pears.

Broken Skin.

Under this category the average mark obtained amounted to 26.7 out of a maximum of 30. Only five entries gained full marks, but in 179 cases the marks were 25 or over. Four entries received 20 marks, while one sample was given only 13. Most of the broken skin was evidently caused by injuries received before the fruit was bagged, and not in transit; thus it would have been possible to avoid including the damaged fruits.

Bruising.

The average mark awarded was 7.1 out of a possible 10. No entry was entirely free from bruising, but in 25 cases 9 marks were given. One hundred and forty entries received 7 marks or over, while 4 received 4, and the worst sample only 2 marks. The amount of bruising was apparently largely dependent on the variety.

Extraneous Matter.

The average mark was 18.8 out of a maximum of 20. Samples, on the whole, were fairly clean, considering the wet weather which occurred when many of them were picked. Ninety entries obtained full marks and only 10 entries received less than 16, the worst being given 12 marks.

Total Marks for all Characters.

The average of the total marks obtained by the various entries was 88.8 out of a possible 100. The best sample obtained 98 marks and 16 others received more than 95 marks. At the other end of the scale 19 entries received less than 80 marks, 6 of these entries consisting of pears. The lowest mark, 68, was, however, given to a sample of apples.

Varietal Features.

Where there were numerous entries of certain varieties, an examination of the marks gives some indication of the extent to which good condition of the fruit was associated with particular varieties. Of the apple varieties, the 23 entries of Kingston Black received an average mark of 90, which is slightly better than the general average, but the marks of individual entries of the variety ranged between 96 and 83. The 8 samples of Strawberry Norman obtained an average mark of 91, with a range from 96 to 88, and it is notable that most of the points lost by this variety were for bruising. The variety Frederick had the low average of 83 for 9 samples, but the range was from 95 to 68. Several other varieties of apple obtained averages similar to the general mean but showed a fairly wide range of marks. Pears, in general, gained a lower average of marks than apples, but there were exceptions.

Although some varieties were, on the whole, received in worse condition than the average, the fact that in their case certain entries gained very good marks indicated that, when reasonable care is taken, any variety can be delivered in at least fair condition. Certain varieties, however, such as Strawberry Norman and White Norman, will probably always show a fair amount of bruising, however carefully they are handled.

General Observations.

It is evident from the figures given above that the condition of the fruit sent in for competition differed widely in different samples of the same variety, and it appears that the general level of condition could be raised considerably if sufficient care were taken by the farmer in collecting and despatching his fruit. It would scarcely be possible to improve on the condition of a number of the best entries received, but many of the poorer samples were distinctly below the required standard.

In some cases more care is required in keeping the consignments of fruit true to variety and in avoiding the inclusion of extraneous matter. Some of the bruising found might be avoided by more careful handling. The worst faults, however, are the inclusion of rotten fruits and of fruits with broken skin, as the latter may be rotten before they can be used.

Although some varieties, such as Frederick, and some pears, might appear to be more difficult to deliver in good condition, this is often due to the fruit being kept at the grower's end until too ripe. Such varieties should be separately consigned where necessary and practicable, while still in good condition, rather than be held back—as frequently happens—until they can be delivered with later varieties.

NOTES ON CIDER-MAKING PRACTICES IN EUROPE (1925—37).

By VERNON L. S. CHARLEY.

During the past 12 years six visits have been paid by parties of English cider-makers to France, Germany and Switzerland to study the methods employed in the cider industry in these countries. The visits have taken place as follows :—France (1926. 1933 and 1937), Germany (1928 and 1935) and Switzerland (1931). In each case representatives of the National Fruit and Cider Institute attended with the party, and the following notes have been taken from the technical reports which were prepared after each tour of studies. No attempt will be made to discuss the economic issues associated with the industry in the various countries on account of the difficulty in obtaining the necessary figures. but one general tendency which has been observed in Germany and Switzerland is worthy of note. The introduction of the new unfermented apple drinks in the two countries has had a definitely depressing effect on sales of fermented cider. In Germany the sale of medium sweet types of fermented cider has practically ceased. and the unfermented apple juice is now largely supplied in its place. The cider consumed is almost entirely of the dry type. containing 4—6% alcohol by weight. In France, however, the production of unfermented apple juice is not yet commercially undertaken. although in 1937 one of the largest cider factories installed an "experimental" battery of Seitz-Boehi tanks capable of storing 60.000 gallons of apple juice in an unfermented condition. Although attempts have been made to determine the probable quantitative effect of the non-alcoholic product upon the sales of fermented cider in a number of other European countries. it has not yet been found possible to assemble any definite data on the question.

In this article the various processes concerned in cider-making will be considered in the order in which they naturally occur—all the details from the various countries being discussed collectively.

Fruit.

The high quality of the typical bittersweet varieties of French cider apples is well-known, and the general character of the cider produced in France is determined by the quality of these varieties. Very large quantities of cider fruit are used annually for the production of potable spirit (Calvados) or of commercial spirit which undergoes various forms of purification and fractionation.

In Germany and Switzerland, there is not the same clear differentiation between the true cider and culinary types of apple, and the finished ciders are, in general, less heavy in character and much more acid than the French type.

Storage of Fruit at Factory.

In all three countries emphasis was laid on the importance of milling the fruit at the correct state of maturity, but in France there was the most elaborate provision for obtaining a satisfactory maturity in large bulks of fruit. The arrangements usually consisted of cement silos with channels of running water in the bottom to transport the apples when mature to the mills. In some factories the silos were small, and an attempt was made to keep certain classes of fruit in separate compartments. At the larger factories, however, provision was made for very large vessels holding, in some cases, 1,000 tons of fruit.

Washing of Fruit.

The wide application of washing machines in the three countries under review was significant. Most of the machines were of an improvised nature, but some form of plant was included in the equipment of all factories. Washing was generally achieved by transporting the apples from the silos to the mills by means of water running in channels of concrete, or, as in Switzerland, by the action of a continuous screw rotating in a long metal channel, lined with an acid resistant lacquer, filled with water and in which the apples are floating. The insistence of the technicians in the European countries on this thorough washing treatment should be of interest to the English cider industry, for the fruit received at the factories abroad is generally in a remarkably clean state, whilst the same cannot yet be said of the home supplies of fruit.

Milling.

A number of mills of varying types are used on the Continent. In Switzerland, the granite roller mill is still favoured as giving the most efficient disruption of the fruit tissues. In a modern factory at Zug, a new type of mill of a unique design was seen. The apples fall into a vertical cylinder which is closed at the bottom. A mechanical contrivance rotating within the cylinder at 2,000 r.p.m., throws the apples forcibly against saw-edged knives fitted vertically into the outer cylinder. Immediately adjacent to each knife is a small rectangular slit, through which the juice and pomace is forced, and falls down through the shute into the press cloths.

A further point of interest in this connection concerns the development of a type of mill in France which is designed to give the finest possible disintegration of the apple tissue. Whereas in this country there is a definite feeling against obtaining an excessively fine pulp on account of the liability for it to become " mealy " and give a lower yield of juice, the French makers believe that it is impossible to mill the fruit too finely. The " râpe Bidon," which was seen in two large factories, consists of a steel cylinder round the periphery of which are fitted a considerable number of knives, resembling fret-saw blades. These are spaced at about $\frac{3}{8}$ in. intervals around the cylinder, and project nearly $\frac{1}{2}$ in. from the surface. The knives are not inserted at right-angles to the surface, but are inclined towards each other. Very large quantities of fruit can be milled in this type of machine.

Maceration.

The process of maceration has very largely ceased in this country, although at one time it was widely practiced. The visits to other countries showed that although German and Swiss cider-makers had to a large extent given up the maceration process, it was still in general use in France, where great importance was attached to it. In large and small factories alike, there was provision for macerating tanks, and although it was obvious that much extra expense and labour was entailed, all factory executives expressed their faith in the efficiency of this procedure. The milled fruit is received into long rectangular tanks, of varying sizes, but usually about 3 in. deep. The pulped apples are allowed to remain there for a period from 3—12 hours, during which time the free juice is allowed to separate and run away through a channel set in the floor of the tank and covered with a loose open structure of wood. In this way, a considerable removal of juice is achieved, and its final expression is rendered more easy and much quicker, since it involves the pressing of a much smaller amount of material. Unfortunately, the recent visit to France was made before the commencement of the milling season, and it was not possible to see the process in operation, but the removal of the macerate from the tanks to the cheeses would appear to be an awkward as well as time-consuming operation.

During discussions on the theoretical reasons for and against maceration, it was found that some diversity of opinion existed. The main contentions were that maceration led to an increase in colour, yield and aroma in the juice, and that the best ciders were produced only by this procedure. The opponents of the process insisted that maceration provokes acetification, reduces the tannin content of the juice, and leads sometimes to an excess colouration and sometimes to an almost complete decolouration of the juice. Professor Warcollier's attitude to this problem was that maceration is always necessary, and that the freshly milled pulp should never be pressed out at once. By adopting various means of maceration, pale or coloured juices, rich or deficient in tannin, and possessing special characters with regard to ultimate clarification and rate of fermentation can be made as desired. In his text-book, "Le Cidrerie" (p. 101), Warcollier gives the general principles on which the present practice of maceration is based. The following points have been abstracted from the full statement.

> "Maceration out of contact with air ought not to exceed 24 hours duration ; longer periods give rise to commencement of fermentation, loss or aroma and the acquisition by the juice of unpleasant tastes. For ordinary maceration in contact with air, twelve hours treatment should never be exceeded, and often six hours is sufficient. Certain varieties with low acidities and in which the tannin oxidises rapidly should not be left to macerate for more than three hours.
>
> The use of vessels with false bottoms results in a removal of juice equivalent to 15% of the total weight of the pulp, and thus reduces the quantity of pulp to be treated in the press to this same extent."

Pressing.

Hydraulic presses are now in univeral use, but some differences in design have been seen. In Germany and Switzerland, where maceration is not practiced to any great extent, swivel presses are the rule. The pulp is measured in equal quantities through an extensible chute into the cloths. When the cheese has been completed, the base is swung round under the hydraulic press, and a duplicate base returns under the mill and is ready for the erection on it of a further cheese. As the trolley system is thus obviated, the alternative method appears to possess certain considerable advantages. In Switzerland the practice is to use two presses, the first to give a medium pressure, and the second, with a much smaller base, to exert a very heavy pressure on the disintegrated pomace from the first press.

In France, the procedure varies considerably. In some factories a series of medium sized presses are installed, each press being associated with a separate maceration tank, and rails are laid between the tanks for the transport of the pulp from the tank (where the cheese was actually built) to the press itself. In other cases, very large units are favoured, and exceptionally heavy working pressures are used.

Keeving.

This process is peculiar to France, but, as in the maceration procedure, it was in general use. The juice is led from the press to large open tanks, of an average depth of 3 feet. The duration of the keeving period varies considerably, but in general lasts between 3—8 days. Various points were raised when the question of the necessity of keeving was discussed. Four main processes are involved :—

(i). Coagulation of pectinous substances, in a juice in which no fermentation whatever is proceeding.

(ii). The separation of the coagulated material into top and bottom deposits.

(iii). A very slight fermentation to form a brown head and a settlement of the lees, with consequent clarification of the liquor.

(iv). Withdrawal of clear liquid from the top and bottom deposits.

The following practical points arise in connection with these 4 procedures :—

(i). Keeving must be done at low temperatures. Whilst it is advisable to work at 0°C, fair results can be obtained at temperatures below 6°C. In one factory, elaborate refrigerating machinery was installed for the express purpose of maintaining the juice at a very low temperature during the 8 days needed for complete defecation. Where refrigeration is not feasible slight amounts of SO_2 are used to prevent fermentation. (100 parts per million of SO_2 will usually suffice).

(ii). If defecation does not take place immediately, certain materials can be added. Amongst these are soluble bicalcium phosphate, calcium saccharate, and tartaric acid in association with chalk. These compounds have most effect if added to the pulp immediately after milling. A further method for inducing defecation is to add the juice of certain pears rich in pectase ; this method has been used in Switzerland for some time, and special varieties of pears (Scheidmostbirnen) are cultivated specially for this purpose. Pear pomace has a similar effect in the maceration of juices which are only defecated with difficulty.

(iii). The slow fermentation will generally commence spontaneously. If low temperatures are used, however, the raising of the temperature by one or two degrees will be sufficient to start a fermentation. A very slow fermentation extends the necessary duration of the keeving but does not detract from its success ; but a rapid fermentation leads to the formation of a white head and poor clarification.

(iv). In racking off the clear juice, every care should be taken to prevent the removal of any of the deposit with the juice. The thick material can be allowed to settle again, and a further portion of liquor removed.

Fermentation.

(*a*). *At Low Temperatures.*

One of the most significant observations made during the 1937 visit to France was the remarkable increase in the use of refrigeration both for preventing fermentation in the production of a practically unfermented juice, and for controlling fermentation in the normal cider making procedure. The former is referred to in a later section on naturally sweet ciders, but mention is made here of the use of low temperatures to ensure a very slow, regular fermentation. The keeved juices naturally possess a rather low rate of fermentation, but such is the importance which is attached to a slow fermentation that many factories now ferment the juices under strictly controlled temperature conditions, and elaborate ice machines were found in large and medium sized works.

(b). *Selected Yeasts.*

The extensive use of pure yeast cultures for the fermentation of apple juice is confined to Germany, and in that country it appears that practically all the fermented cider was made in this way. The detailed procedure was seen at a large factory in Frankfurt, and the salient features will be outlined below. In order to obtain a dominant fermentation with one particular type of yeast, the natural and wild yeasts must first be removed from the juices. This is effected in most cases by the centrifuge, although pasteurisation is sometimes used. The fresh juice from the press is passed straight through a centrifuge rotating at high speed, and during its passage through the bowl the majority of the yeast cells are removed by deposition on the walls of the rotating cylinder. The juice, thus rendered practically free from its normal yeast population, is then inoculated with a culture of a pure yeast which has been activated by being allowed to develop in a small quantity of juice in which all micro-organisms have been killed. The cultures are supplied either by special agencies or by State Research Stations such as Geisenheim, and many thousands of liquid cultures are despatched to cider and wine makers each season. New cultures are generally sent each fortnight and usually consist of 200—300 ccs of media in which the yeast has developed. This is used to inoculate the yeast into about 1 gallon of sterile juice. This large culture, in its turn, is inoculated into 20 gallons of sterile juice, and the " starter " is increased in bulk until there is sufficient active material to inoculate the large bulk of juice at a rate of from 2—5%. The ciders which result from this type of fermentation are always allowed to ferment to dryness in order to accentuate the special character imparted by the yeast itself, and the lees are not removed for some months after the cessation of fermentation. Very wide use is made of wine yeasts for apple juice fermentation. Cultures of Steinberg, Waldenberg and Zeltingen have been procured by the Long Ashton Station, and have been used for several series of experiments during 1936-7. Fermentation has been protracted in nearly all cases, but definite improvements have been noted in most of the treated ciders. The ciders tasted in Germany were remarkable for their fine aroma and bouquet, and they possessed a distinct and attractive vinous character that was quite different from the taste of ordinary cider.

Filtration.

The demand for a brilliant finish for fruit beverages appeared to be most insistent in Germany, for all ciders were completely devoid of haze or clouding. The earlier visit to Germany had helped towards the widespread use of the Seitz sterilising filter in this country, and the latter tour confirmed the earlier impression that cold process sterilisation was exclusively used for cider. Much cider is still sold in France in a hazy condition, but filtration is being adopted rapidly, both as a means of producing naturally sweet cider and as an efficient method of clarification. A feature of French pulp filters is their design in four sections so that a continuous filtration can be carried on, whilst each section can be by-passed for cleaning.

Naturally Sweet Cider.

It has been mentioned previously that refrigeration is being increasingly used in France to provide a slow main fermentation in the keeved apple juice. The final products of this process are usually of medium sweetness, but the loss of flavour and aroma associated with even this moderate degree of fermentation is evidently regarded as serious, for a new process has recently been adopted in which one half of a bulk of juice is maintained in a totally unfermented condition, whilst the other half is allowed to ferment to a very low gravity. The two products, one an unfermented apple juice and the other a fully fermented cider, are blended shortly before consumption, and it is claimed that the freshness of apple character imparted to the final product by the use of the unfermented juice is a great improvement on the character of cider made by other means. In 1937 a very large factory was visited near Paris, where cider was made in this way. The juice which was to be retained in an unfermented condition was stored in large glass-lined tanks built into a massive structure. Each vessel was cooled by a series of refrigerating coils contained within the tanks, and the filtered juices were kept at a little above 0°C. The fully fermented ciders were racked from their deposits and blended in the juices as occasion demanded. Very attractive ciders were made by this method.

Champagne Cider *(quick process).*

During recent years the Charmat process for champagnisation of wines has been successfully adapted for the production of a naturally sparkling cider. The process is as follows :—Naturally sweet ciders or sweetened dry ciders are used for the process. Filtered ciders are desirable, but in any case the juice is pasteurised by a large electrode in a steel, glass-lined tank, capable of being sealed and of withstanding much pressure. The sterile juice is then inoculated with an active culture of a pure wine yeast, and the vessel hermetically sealed. The temperature is controlled to give the necessary degree of fermentation in about 7—10 days. During this time the pressure in the tank increases to about 80 lbs/sq. inch and the slow evolution of CO_2 enables the cider and the CO_2 to become intimately associated together. When the pressure has increased to the desired figure. further fermentation is prevented by the cooling of the contents of the tank by means of cooling coils traversing the inside of the vat. The cider is cooled to just above its freezing point for five days. The low temperature accelerates the deposition of yeast material and coagulated matter, which settle to the bottom of the tank. The supernatant liquor is then filtered under isobarometric pressure through a special Charmat filter, consisting of a large number of woven cotton discs placed over a perforated steel bar and pressed extremely tightly together to form a filtering surface.

The advantages of the process are :—

(1) Only 3 or 4 weeks are needed for its completion.

(2) A brilliant, naturally-conditioned cider, with a full vinous character is obtained in which there is little fear of further deposit or haze occurring.

Samples of the products made by this Charmat process have been tasted on several occasions, and the concensus of opinion is that the process is worthy of investigation to determine its suitability under our own specialised conditions.

A further point of interest connected with this process was the " Frigibar " method of dispensing the champagne cider. Double-walled metal containers, the inner one being lacquered, are filled with the conditioned cider as it comes from the filter. The drums are tightly sealed, and transported to the retailer. The vessel is then placed in a cooled cabinet fitted with an attractive superstructure representing an inverted bottle. The cider is forced out of the metal vessel by counter pressure and is delivered in its natural condition through the attachments for this purpose. The above unit can be seen working in batteries at terminal stations in Paris, as well as in the large stores and hotels.

Storage Vats.

Glass or bitumen lined vats are now universally used on the Continent for the storage of cider. Three main materials appear to be used. In all three countries the Swiss " Ebon " lining was in wide use and gave general satisfaction on account of the absence of any taste effect and the complete lack of evaporation from the tanks. In France, a further material, " Etanchis " was in considerable evidence, whilst in Germany and France " Mamut Ventur " was used for similar purposes. In France, keeving and fermenting vats were often made of steel, but in general the storage vats had a base of concrete.

INVESTIGATIONS ON FRUIT PRODUCTS.

XI.—EXPERIMENTS IN FRUIT SYRUP PRODUCTION.

A. METHOD OF EXTRACTION AND PRESERVATION OF FRUIT JUICES FOR SYRUP MAKING.

B. EFFECT OF SUGAR CONCENTRATION ON RETENTION OF FLAVOUR IN SYRUPS.

C. PRESERVATION OF SYRUPS BY HEAT AND CHEMICAL TREATMENTS.

By VERNON L. S. CHARLEY.

The previous investigations on Fruit Products which have been included in the present series commenced in 1932 with the preparation in the laboratory of a range of heavy fruit syrups which were either bottled without any further treatment, or were boiled to aid clarification and to produce an efficient sterilisation of the syrup (1). The next stage was the production of less sweet syrups, for which more stringent methods of preservation were required, and these were elaborated (2) and large-scale commercial production of English fruit syrups became an established fact in 1936-1937 (3). Throughout the period 1932-7 great emphasis was placed on the importance of obtaining a completely cold process for syrup manufacture, and this was eventually achieved. During this time, however, it had been suggested that, whilst the cold process might have many advantages when applied to fruits which are normally consumed in a fresh (*i.e.* uncooked) state, other fruits, such as black currant and blackberry, might conceivably respond better to methods of manufacture involving heat at some stage or other. In this connection the American procedure (4) of heating the fruit previous to expressing the juice was recalled, and it was decided, in the first place, to carry out experiments relating to various methods which were considered to be of interest for obtaining the juice from the fruit.

In the second place, the very considerable financial outlay involved in the provision of suitable storage for the finished syrups indicated the possible value of a process which would allow of the storage of the juice for long periods and the ultimate conversion of the juice, after storage, into syrup. The saving which would result in storage accommodation is obvious, for one gallon of juice becomes about 1.7 gallons of 55% sugar syrup after the incorporation of the solid cane sugar into the juice. Apple and grape juices are both stored satisfactorily without the need for their conversion into syrups or concentrates, and it was decided to discover whether the juices from English soft fruits would deteriorate during long term storage, and whether this method would offer any possibility of commercial development.

Thirdly, it had become important to determine whether the sugar concentration of syrups bore any relationship to the behaviour of the syrups from the points of view of flavour retention and freedom from fermentation. These considerations were extended to include a general preliminary survey of various methods of preservation of syrups of differing sugar strengths.

The points raised in the preceding introductory considerations were examined during the season of 1936, when a comprehensive series of experiments were carried out on six different English fruits—strawberry, loganberry, raspberry, cherry, black currant and blackberry. As certain similarities existed in the results for some of the fruits, only a selection of the full experimental results are given in the succeeding sections of this report, in which data relating to the three subjects mentioned in the title are presented and discussed.

A. METHOD OF EXTRACTION AND PRESERVATION OF FRUIT JUICES FOR SYRUP MAKING.

Method of Fruit Juice Extraction.

Four different treatments were chosen to represent extreme conditions during extraction. These were :—

1. The fruit was milled and pressed out immediately.
2. The fruit was allowed to ferment in wooden vessels for 3 to 5 days. Fermentation was allowed to proceed until a noticeable froth was formed, and at this stage

the juice was expressed. In the case of strawberries and raspberries this amount of fermentation reduced the viscosity of the juice to a value only slightly greater than that for water.

3. The fruit was milled and 0.3% Filtragol added and allowed to act for varying periods.
4. The fruit was milled to a pulp and then heated in a steam-heated copper jam-pan for ½ hour at 160°F. The fruit was kept well stirred to prevent burning or overheating, but no water was added in any of the experiments.

The experiments were done on bulks of half a cwt. of each fruit. The juices, after expression from the fruit, were filtered where possible, and immediately converted into syrups with 50% sugar by weight, which were then preserved with SO_2.

The results of 4 of the series are given in Table I.

The various observations in Table I will be considered for each fruit separately.

Strawberry. In the strawberry, the highest yield was given by the fermentation treatment. This gave a fruit material which was easy to press and a juice which was clear and easily filterable. The fermentation had effected a remarkable disruption of fruit tissues and the large aggregates of fruit were progressively broken down into a sludge-like material. The effects of the enzyme treatment were practically identical with fermentation, except that a slightly lower yield was obtained. During the enzyme treatment only a very slight fermentation had commenced, and the result of this particular experiment is consequently not vitiated by any effects due to the yeast action. The fruit which had been heated for 20 minutes at 160°F. was extremely thick in consistency and was slimy and very viscous. However, the expression of the juice did not offer any difficulties, a stable " cheese " was erected, and the hydraulic press was able to force out a large quantity of thick viscous juice. The chief difficulty with this treatment was the cleaning of the cloths, and the removal of the soft cake of fruit after the pressing. The fruit that was milled and pressed at once presented surprisingly little difficulties in pressing but the juice was thick and viscous.

In each case it was possible to obtain a brilliant juice by pulp

TABLE I.

Methods of Fruit Juice Extraction and their Effect on Ultimate Syrup Flavour.

Fruit.		*Treatment.*	*Yield of Juice in Gallons per cwt. Fruit.*	*Condition of Juice.*	*Ease of Expression of Juice.*	*Syrup Characters.*		
						Aroma.	*Flavour.*	*Conditions of Syrups after 18 months storage.*
Strawberry	(1)	Milled and pressed immediately	9	Thick.	Easily pressed.	Very slight.	Thin and lacking in fruit character.	Clear on top : flocculent deposit.
,,	(2)	Fruit fermented 3 days ..	10	Less viscous.	,, ,,	Clean but less intense than (4).	Brisker than (4). Very fresh and clean.	Clear : heavy pectin deposit.
,,	(3)	0.3% Filtragol. 36 hours .	9½	Practically clear.	Very easy	Similar to fermented syrup.	Similar to fermented syrup.	Clear : slight deposit
,,	(4)	Fruit heated 160°F. for ½ hour	8½	Very thick and viscous.	Easily pressed.	Full and fruity.	Full but " cooked " taste very noticeable	Cloudy : heavy pectin deposit.
Black Currant	(1)	Milled and pressed immediately	6	Very thick: similar to (4).	Very difficult.	Very slight.	Very little flavour.	Thick layers of tissue on top and bottom. Clear between the deposits.
,, ,,	(2)	Fruit fermented 5 days ..	7	Quite liquid.	Easy.	Good fruit aroma.	Slightly inferior to (4)	Very slight cloud. No deposit.
,, ,,	(3)	0.3% Filtragol. 3 days	6	Clearer than (2)	Easy.	Similar to (2)	Full, true, clean, fruit flavour.	Clear : No deposit.
,, ,,	(4)	Heated 160°F. for 20 mins. ..	7	Similar to a purée.	Impossible to obtain juice without tissue.	Full and true.	Very full. Not noticeably cooked.	Solid hard jelly.
Cherry	(1)	Milled and pressed immediately	5	Very thick.	Very difficult.	Slight.	No flavour.	Cloudy. More deposit than (2).
,,	(2)	Fruit fermented 3 days ..	6¼	Viscous.	Difficult.	,,	Inferior to (4). Very slight flavour.	Clear. Slight deposit.
,,	(3)	0.3% Filtragol. 3 days ..	7	Juice almost clear.	Easy.	,,	Fair. Weak fruit character.	Faint haze : slight deposit.
,,	(4)	Heated 160°F. for 20 mins. ..	7¼	Fairly liquid.	,,	,,	Definite but slight cherry flavour.	Cloudy.
Blackberry	(1)	Milled and pressed immediately	7	Less viscous and more clear than (4).	Easy.	Slight.	Very little taste.	Thick gelatinous deposit.
,,	(2)	Fruit fermented 3 days ..	7	,, ,,	,,	,,	,, ,, ,,	Clear. Slight deposit.
,,	(3)	0.3% Filtragol. 3 days ..	8	Much less viscous. Practically clear.	,,	,,	Good fruit flavour.	Brilliant. Very slight deposit.
,,	(4)	Heated 160°F. for 20 mins. ..	7	Thick and viscous.	,,	,,	Very little taste of fruit.	Solid jelly.

filtration, although this was only achieved with difficulty in the case of No. 4., and after several filtrations in the case of No. 1. The syrups, tasted after 18 months storage at ordinary temperatures of 60°—70°F., showed interesting differences. The fermentation and enzyme treatments resulted in clean freshly flavoured syrups which possessed true fruit aroma and character. The heated fruit juice was converted into a syrup which was full and fruity although the latter character was definitely of the " cooked " type. The control syrup which was made immediately from untreated fruit was thin and lacking in fruit character. From the point of view of deposit, the enzyme treatment was most effective, but all the other three methods of extracting the juice gave a syrup which quickly deposited varying amounts of flocculent material. Syrup No. 4 was very thick in consistency with a slight tendency to gel.

Black currant. The yield of juice was equal from the heated and from the fermented fruit material, and appreciably less from the other two treatments, but the methods which had to be employed to obtain these quantities of juice varied very considerably. The heated fruit become practically a solid gelatinous mass of fruit material and on attempting to express the juice it was found to be impossible to prevent the loss from the cloths of much solid material. This juice was, in fact, obtained in the form of a thick purée. A similarly difficult pressing was encountered with the fruit which was milled and pressed at once. The fermentation treatment, on the other hand, which was allowed 5 days for completion, gave remarkable results. The material became progressively thinner, and was pressed with ease, yielding a juice which was only slightly more viscous than water. The 3 days' treatment with enzyme gave even better results, and a practically brilliant juice was obtained. The syrup characters in the four cases raise two interesting points. The heat treatment did not adversely affect the flavour of the syrup. It was full and intense, possessing only a slight background of cooked taste, the flavour being still quite easily recognisable as that of black currant. The fermentation treatment had spoilt the flavour to some extent, by reducing the characteristic aroma and flavour of the fruit. There was a noticeable flavour present similar to the type of fruit flavour associated with black currant lozenges and other forms of confectionery. The syrup flavour had lost its freshness, and had become somewhat dull and uninteresting. The filtragol treatment gave the best all-round syrup for whilst it was not so intensely flavoured as the heated sample, it was clean, fresh and very characteristic of the fruit. The untreated fruit gave a syrup which had very little aroma or flavour.

The appearance of the syrups varied very considerably. The heated material gave a purée which, after the incorporation of the sugar, soon set into a hard, solid jelly. The product made from the untreated fruit soon settled into two very heavy layers of fruit tissue and pectin separated by a clear, pale yellow syrup. The enzyme treatment gave a syrup which remained brilliant and free from deposit for over 18 months. Fermentation of the fruit resulted in a syrup which gradually developed a slight cloud, but no deposit was formed.

Cherry. Napoleon cherries were used for these experiments. With this fruit the best yields were obtained with heat and enzyme treatments ; fermentation was not quite so efficient, and the fruit that was milled and treated at once gave the lowest yield in the whole series of experiments. Once again the enzyme-treated fruit gave the best juice. It was practically clear, and needed only a very light filtration to make it brilliant.

The syrups were not generally attractive. No really intense, characteristic flavour of cherry was present in the syrups, and the major impression on the palate was of a heavy, somewhat sickly flavour of little interest. The only treatment from which any sign of cherry flavour resulted was that in which heat was used, whereas the other three syrups were lacking in general fruit character. All syrups developed some opacity and deposit during storage.

Blackberry. Enzyme treatment gave the best yield, and the other three treatments produced identical results. The general nature of the pressing treatment and the condition of the expressed juices were similar to those for black currant. The syrups all possessed very little flavour, with the exception of the enzyme-treated sample, which alone exhibited a true blackberry flavour. The syrup from the heated fruit became a solid gel. No. 1 maintained a liquid state, but deposited a thick gelatinous layer. The fermentation process enabled the syrup to remain clear with only a slight deposit over an 18 month period, whilst the enzyme method gave a brilliant syrup with only a trace of deposit.

Considering the experiments as a whole, it appears that enzyme treatment will produce the highest yield and the truest and fullest flavour in the syrup. With strawberries the heat treatment could not be considered to have affected the flavour to a serious extent, whilst with heated black currants a very full flavour was obtained. Heat treatment was also the only method which gave a noticeable cherry flavour.

Preservation of Fruit Juices for Ultimate Conversion into Syrups.

The results of experiments on methods for the storage of juices in their natural state are given in Table II.

A volume of juice sufficient to cover all the treatments for one fruit was filtered to a brilliant condition by a pulp filter and then treated according to the details given in Table II (column 2). After 12 months, the juices were examined and converted into syrups (using 50% sugar by weight) for tasting. In most of the series it was possible to get a comparison in flavour by using a sample from one of the other series of experiments, since the investigations discussed in this report were proceeding simultaneously, and the same bulks of fresh juices were used for all the experimental work.

With regard to the keeping properties of the juices, the pasteurised samples were all quite sound, whereas slow fermentation occurred in the Seitz filtered cherry juice and the strawberry juice preserved with 200 p.p.m. of SO_2. It would appear that with extra precautions in the use of the Seitz E.K. filter and with the use of higher doses of SO_2 there should be no difficulty in keeping soft fruit juices in bulk free from fermentation or other microbiological effects.

Chief interest, however, attaches to the flavour of the juices themselves after the 12 month storage period. The flavour of strawberry juices prepared and stored according to the scheme in Table II had seriously deteriorated, and the syrups made therefrom were similarly open to criticism. The first syrup, made from cold sterilised juice, had lost all its fruit character. A flavour similar to that previously noticed in strawberry wines (4) was apparent, although no fermentation whatever had proceeded in the juice. The second syrup was more fruity than the first sample, but the taste was definitely " cooked." The other two syrups were preserved with SO_2 and a slow fermentation had affected the flavour of No. 3. But in no single case were the syrups as attrative as samples of syrups which had been made up immediately, and it would not seem advisable to consider the storage of strawberry juice for the purpose of producing syrups at a later date.

The results for cherry were similar to those for strawberry and need no further discussion.

With loganberry, however, the case was different. The juices after storage were found to have retained their natural flavour to a full degree, and syrups made up from the juices after 12 months storage, on comparison with syrups made in the usual way, were

TABLE II.

PRESERVATION OF FRUIT JUICES FOR ULTIMATE CONVERSION INTO SYRUPS.

Fruit.	*Treatment of Juice before storage.*	*Condition of Juice after 12 months storage.*	*Quality of Syrup Made from Juice after 12 months storage.*
Strawberry (1)	Seitz E.K. filtered into sterile jars.	No bacterial or yeast growth. Slight deposit.	Fruit flavour disappeared.
,, (2)	Clarified and pasteurised in bottle at 165°F. for ½ hour.	Brilliant. No deposit.	More fruit character than (1), but pasteurised taste noticeable.
,, (3)	Clarified and 200 p.p.m. SO_2 added.	Slight fermentation.	Slight fermented taste. Fruit character completely lost.
,, (4)	Clarified ; acidity raised to 5% (citric acid) and 200 p.p.m. SO_2 added.	Brilliant. Faint deposit.	Very sharp, but otherwise similar to (3).
Cherry (1)	As for Strawberry (1)	Slight fermentation.	Fruit character disappeared. Cherry wine flavour noticeable.
,, (2)	,, ,, ,, (2)	Brilliant. Slight deposit.	Same as for Stawberry (2).
,, (3)	,, ,, ,, (3)	Clear. Slight deposit.	As for Cherry (1).
,, (4)	,, ,, ,, (4)	Cloudy. Slight deposit.	,, ,, ,, ,,
Loganberry (1)	As for Strawberry (1)	No fermentation, clear juice. Slight deposit.	True fruit flavour. Intense and clear.
,, (2)	,, ,, ,, (2)	,, ,, ,,	True flavour, only slightly pasteurised taste.
,, (3)	,, ,, ,, (3)	Faint haze. Slight deposit.	Full and true loganberry flavour.
,, (4)	,, ,, ,, (4)	Clear ; flocculent deposit.	Full and true loganberry flavour, but excessively sharp.

excellent in quality. It is interesting to note that in a previous investigation on fruit wines, raspberry and loganberry products retained a proportion of fruit character, whilst strawberry and black currant flavours were almost completely lost (5).

In a previous season, a series of raspberry juices were preserved according to the present scheme, and the data then obtained indicated that raspberry and loganberry fruits could be considered as giving similar results.

It thus appears that, whilst strawberry and cherry juices do not lend themselves to syrup production by the method discussed in this section, raspberry and loganberry juices can be kept for long periods without suffering any vital deterioration in flavour.

B. EFFECT OF SUGAR CONCENTRATION ON RETENTION OF FRUIT FLAVOUR IN SYRUPS.

Some earlier experiments had indicated that the freshness and intensity of the true fruit flavour of syrups after storage was affected by the concentration of sugar in the syrup, and in 1936 a series of syrups were made up from the more important soft fruits to establish whether any such relationship did actually exist. The syrups were all made from juices which had been given identical treatment in extraction and processing. Low sugar syrups were preserved with 250 p.p.m. of SO_2. The flavours were noted after varying periods of storage, but the data given in Table III referring to these experiments applies to the latest tasting which took place in January 1938, eighteen months after the production of the syrups.

Only three series of observations are given, those for raspberries being omitted since the results approximate closely to those for the loganberry. In each case, a heavy syrup of 65% sugar content was made and no preservatives were added. Two further syrups with 50% and 30% sugar were made and preserved with 250 p.p.m. of SO_2.

It is obvious that the intensities of total flavour of the syrups in any one fruit series should be widely different. The heavy syrups with 65% sugar contain only 51% juice by volume, whereas the 50% and 30% sugar syrups contain 66% and 82% juice respectively. The observations on flavour given in Table III must be considered with this fact in mind.

TABLE III.

EFFECT OF SUGAR CONCENTRATION ON RETENTION OF FRUIT FLAVOUR IN SYRUPS.
(Acidities adjusted to a minimum of 1.0% citric acid by weight).

Fruit.	*Sugar Content of Syrup per cent.*	*Method of Chemical Preservation.*	*Syrup Characters (after 18 months storage).*		
			Aroma.	*Flavour.*	*Condition of Syrup.*
Strawberry (1)	65	—	Weak, but fresh and fruity.	Very true, fresh fruit character.	Almost clear. Pectin deposit.
,, (2)	50	250 parts of SO_2 per million.	Much stronger.	Stronger flavour. Attractive, and fruity.	Clear. Heavy deposit.
,, (3)	30	,,	Fruit aroma completely lost.	Flavour changed into vinous type.	Brilliant. Flocculent deposit.
Loganberry (1)	65	—	Full and fresh.	Clear and characteristic of fresh fruit.	Slight cloud, with thick deposit.
,, (2)	50	250 p.p.m. SO_2	Very full and aromatic.	Very full, fresh flavour.	Clear. Slight deposit.
,, (3)	30	,,	Full but not true.	Very full flavour, but not quite true to fruit.	,, ,,
Cherry (1)	65	—	Slight.	Very sweet, but clean fruity flavour.	Clear. Slight deposit.
,, (2)	50	250 p.p.m. SO_2	,,	Sweet, but slight flavour.	Clear. Very slight deposit.
,, (3)	30	,,	Fuller but quite unlike fruit.	Full, but definite loss of true fruit character.	,, ,,

The strawberry series showed wide differences in character. The heavy syrup possessed a true fruit character, but it was weak, and when the syrup was diluted to a reasonable degree of sweetness (1 + 7) the flavour was only barely recognisable as that of the fruit concerned. As the base for a fruit beverage, it was not sufficiently flavoured, although, as has been mentioned, the flavour was true. The 50% sugar syrup possessed a much more penetrating and fruity aroma, and the flavour showed a similar improvement in intensity. The diluted product was flavoured sufficiently strongly. Only a very slight taste of SO_2 was noticeable after the earlier observations, and it was completely absent after 6 months. The lowest sugar syrup, however, presented entirely different characters. The flavour of the fresh fruit had entirely disappeared, and in its place a vinous character was observed. This was not the result of fermentation, for the 30% sugar syrup in this series was perfectly stable. The character was reminiscent of the "sherry" flavour which was noticed in a series of alcoholic wines made from strawberries (5). The earlier tastings of this syrup indicated that the transformation of the flavour commenced after about 6 months, and that before this, the syrup was remarkable for its full and intensely true, fruit character. In the later stages of storage, fermentation definitely occurred although no deposit was formed and only slight gas pressure was noted on opening the bottles.

The loganberry series presented very similar results to the strawberries, with the exception of the syrup with the lowest sugar content which possessed a flavour still easily recognisable as that of the fruit after 18 months. This last syrup approximates in composition to the " sweetened loganberry juices," which are sold on the North American Continent for consumption after only slight dilution. In this form, the syrup under consideration formed a very attractive base for a beverage, but when the 50% and 30% syrups were diluted to equal gravities, the superiority in flavour in the former was noticed.

In another series of experiments, raspberry syrups were found to be similar to the loganberry series, excepting that the change in flavour in the lowest sugar syrups was very marked. It was almost impossible to distinguish between the syrups made from the two fruits, as the original special characters of the fruits had disappeared, leaving a flavour common to both.

Cherry syrups were included in the experiments for two reasons. In the first place, the treatment of the fruit material and the nature of the syrups themselves were so different from the berry fruits and their products. Secondly, attempts have been made at Long Ashton to produce a high-class cherry syrup with the characteristic flavour of the fruit, and in view of the unsatisfactory results obtained, the fruit was included in the present series of experiments to discover whether any improvements of flavour would result.

The heavy syrup possessed a slight aroma, and such flavour as was present was clean and reminiscent of the cherry. The 50% sugar syrup appeared to be no stronger in flavour than the preceding sample, whilst there was a full flavour in the weak syrup, but it was not at all characteristic of the fruit. This last syrup was not attractive.

From a consideration of the above observations, it appears that high sugar concentration is necessary for the minimum retention of fruit flavour. Lower sugar syrups are liable to undergo considerable changes in flavour. The inclusion in the experiments of a syrup with 50% sugar has allowed observations to be made on the behaviour of syrups of approximately commercial standards, and the flavour retention of such syrups was satisfactory.

C. PRESERVATION OF SYRUPS BY HEAT AND CHEMICAL TREATMENTS.

In the earlier stages of the fruit syrup investigations, it was decided to concentrate attention upon the production of cold processed fruit syrups. This fact, coupled with the need to obtain syrups with much less sugar than 65%, necessitated the use of preservatives. Following the lead of most manufacturers who were using fruit for various purposes, SO_2 was chosen as the preservative with which to carry out the sterilisation of syrups and of plant and utensils. But at a later date, the claims of benzoic acid were considered and differences in keeping quality and flavour were noted in the syrups preserved by this second chemical. At this period came the introduction of the hydroxybenzoic esters used in Germany as preservatives, and these too were included in the tests. Finally, the use of heat pasteurisation was considered as a possibility in some cases, and consequently a preliminary comparison of the efficiency of these various methods was attempted to determine the best for possible commercial developments.

The details of the syrups used, the means of preservation adopted, and the condition and flavour of the syrups after storage are given in full in Table IV for strawberry, and Table V for loganberry.

It is not necessary to subject the results in Table IV to much discussion. The safe keeping of strawberry syrups appears to be a most difficult procedure, but it should be noted that the syrups included in Table IV had not been acidified, and it has since been definitely proved that the acidity of a syrup is almost as important a factor as the preservative for the keeping of the product. The benzoic acid experiments deserve special note. This chemical does not seem to be so effective a preservative as SO_2 (see Nos. 10, 11, 12), but when advice was sought in 1937 regarding the canning of fruit syrups, it became desirable to investigate the possibility of benzoate preservation, in view of the inability of ordinary cans to be used with SO_2. A bulk of 800 gallons of strawberry syrup was adjusted in acidity to 1.0% and preserved with 600 p.p.m. of benzoic acid in the form of the sodium salt. Slow fermentation ensued after several weeks, but after an efficient filtration the syrup was stabilised for some months, but eventually a very slow fermentation again commenced. During the early weeks of storage the benzoate preserved syrup was definitely fuller and stronger in flavour than the control syrup (with SO_2), but gradually the position was reversed, and after 6 months storage the benzoate product

TABLE IV.

EFFECT OF METHODS OF PRESERVATION ON STABILITY AND FLAVOUR IN STRAWBERRY SYRUPS.

No.	*Sugar Content of Syrup per cent.*	*Method of Preservation.*	*Syrup Characters (after 18 months).*		
			Stability.	*Aroma.*	*Flavour.*
(1)	65	—	No fermentation.	Weak, but true to fresh fruit.	True to fruit, but excessively sweet.
(2)	50	350 p.p.m. SO_2	,,	More attractive than (1).	Much better syrup than (1).
(3)	50	250 ,, ,,	,,	Full aroma.	,, ,,
(4)	50	150 ,, ,,	Signs of fermentation.	,, ,,	Fermented taste.
(5)	50	50 ,, ,,	,, ,,	,, ,,	,, ,,
(6)	30	350 ,, ,,	Much fermentation.	Vinous aroma.	Flavour similar to that of strawberry wines.
(7)	30	250 ,, ,,	,, ,,	,, ,,	,, ,,
(8)	30	150 ,, ,,	,, ,,	,, ,,	,, ,,
(9)	30	50 ,, ,,	,, ,,	,, ,,	,, ,,
(10)	30	300 ,, ,, benzoic acid.	Fermentation commenced after 4 months.	,, ,,	Flavour was fuller than corresponding SO_2 samples until fermentation commenced. Flavour then rapidly deteriorated.
(11)	30	600 p.p.m. benzoic acid.	,, ,,	.. ..	.. ..
(12)	50	300 ,, ,,	,, ,,	,, ,,	,, ,,
(13)	50	600 ,, ,,	Very slight fermentation.	,, ,,	,, ,,
(14)	30	10 p.p.m. Nipagin.	No control over fermentation.	,, ,,	Fermentation quickly ensued in Expts. 14-17 and the fruit flavours of the syrups were very quickly lost.
(15)	50	,, ,,	,, ,,	,, ,,	
(16)	30	10 p.p.m. Nipasol.	,, ,,	,, ,,	
(17)	50	,, ,,	,, ,,	,, ,,	
(18)	50	300 p.p.m SO_2	Very slight fermentation.	Clean and fresh.	Clean, fresh fruity flavour. Quite intense.
(19)	50	Pasteurised at 165°F. for ½ hour.	No fermentation.	Clean but lacking in freshness.	Fully flavoured but not quite so attractive as (18).

was flat and lacking in fresh fruit flavour. A flavour similar to strawberry jam had been acquired, and the SO_2 preserved syrup was fresher and more intense in fruit flavour. The colour changes were dissimilar with the two preservatives. Suphur dioxide gave a definite bleaching action, but the colour returned to some extent as the SO_2 became "combined." No such loss of colour was effected by the benzoic acid, but, on the contrary, a gradual deepening occurred, the red shades becoming tinged with brown. With strawberry syrup preserved with benzoate, the colour, after 6 months storage, was a very deep, rich, brownish red, whereas the SO_2 syrup was only a pale, reddish straw colour.

The use of Nipagin and Nipasol (hydroxybenzoic esters) was not satisfactory. These compounds are difficult to get into solution, and the sodim salts are generally used. When solutions of the sodium salts are added to fruit juices there is a tendency for the appropriate acid to be precipitated and separate out. Only strenuous shaking at this stage will achieve the solution of the preservative.

The pasteurisation of strawberry syrup was compared with the cold SO_2 process in experiments Nos. 18 and 19. The results were precisely the same as for fruit juices. The pasteurised product was fully flavoured, but had lost the keen, brisk freshness of the fruit character, and although the flavour could not be regarded as unsatisfactory, it could not compare with the fresh flavour of the cold process syrup.

The results for loganberry syrups are given in Table V.

TABLE V.

EFFECT OF METHODS OF PRESERVATION ON FLAVOUR IN LOGANBERRY SYRUPS.

No.	*Sugar Content of Syrup per cent.*	*Method of Preservation.*	*Syrup Characters (after 18 months).*		
			Stability.	*Aroma.*	*Flavour.*
(1)	65	—	No fermentation.	Very clean and fresh.	Full and characteristic of ripe fresh fruit
(2)	50	350 p.p.m. SO_2	,,	Very full and clean.	Very full, fruity flavour.
(3)	50	250 ,, ,,	,,	,, ,,	,, ,,
(4)	50	150 ,, ,,	,,	,, ,,	,, ,,
(5)	50	50 ,, ,,	Very slight fermentation.	,, ,,	,, ,,
(6)	30	350 ,, ,,	,, ,,	Clean and very full.	Full flavour, but slight taste untrue to fruit.
(7)	30	250 ,, ,,	No fermentation.	,, ,,	Full flavour, but not quite true to fruit.
(8)	30	150 ,, ,,	Some fermentation.	Vinous flavour.	Fruit flavour converted into vinous character.
(9)	30	50 ,, ,,	Considerable fermentation.	,, ,,	,, ,,
(10)	30	300 ,, ,, benzoic acid.	Fermenting.	,, ,,	,, ,,
(11)	30	600 ,, ,,	Much less fermentation.	,, ,,	,, ,,
(12)	50	300 ,, ,,	No fermentation.	Weak.	Inferior to corresponding SO_2 syrup. Much less fresh.
(13)	50	600 ,, ,,	,,	,, ,,	,, ,,
(14)	30	10 p.p.m. Nipagin.	Slight fermentation.	Clean true aroma	,, ,,
(15)	30	10 p.p.m. Nipasol.	,,	,, ,,	,, ,,
(16)	50	10 p.p.m. Nipagin.	No fermentation.	,, ,,	Attractive syrup but inferior to SO_2 series.
(17)	50	10 p.p.m. Nipasol.	,,	,, ,,	,, ,,
(18)	50	300 p.p.m. SO_2	,,	Very full.	Very good syrup.
(19)	50	Pasteurised at 165°F. for ½ hour.	,,	Definite 'cooked' aroma.	Pasteurised flavour very noticeable, but syrup still attractive.

With 50% sugar syrups, it is seen that 150 p.p.m. of SO_2 was sufficient to ensure sterility (No. 4), but that 250 p.p.m. of SO_2

were needed to stabilise a 30% sugar syrup. The lowest sugar syrups were not preserved either by 300 or 600 p.p.m. of benzoic acid, but the lower strength was sufficient to preserve 50% sugar syrups. It is interesting to note that 10 p.p.m. of the two hydroxybenzoic esters did not prevent fermentation in the 30% sugar syrups, but that the same preservatives were effective in the 50% syrups.

The experiments with benzoic acid have been amplified by a series of bulk tests on raspberry, loganberry and black currant, in which the full 600 p.p.m. were used. No fermentation developed, and for a period of 6 months the flavour of the benzoate preserved material was remarkably fresh and intense, especially in the case of the black currant. A very slow deterioration of flavour then commenced, but at a much slower rate than in the strawberry, and after 12 months storage, the benzoate samples of all three fruits were more intense in flavour than the corresponding groups preserved with sulphur dioxide.

The pasteurised product acquired a very pronounced " cooked " aroma and taste, but although this could not be mistaken, the syrup was still attractive, and only suffered by direct comparison with the control, Experiment No. 18.

SUMMARY.

1. Juices were obtained from strawberries, loganberries, black currants, cherries and blackberries by four methods: immediate milling and pressing; enzyme action; slight fermentation; and heating the milled fruit at 160°F. for half-an-hour. The enzyme and fermentation treatments afforded the highest yields of juice and were most helpful in further processing. The heat treatment yielded very thick juices which were extremely difficult to clarify. With regard to flavour, the juice obtained by immediate milling and pressing was very deficient in flavour, and in general, the enzyme treatment produced the most attractive products. Heat treatment did not result in appreciable deterioration of the flavours with the exception of strawberry where a " cooked " taste was noticeable.

2. Filtered fruit juices were stabilised in four different ways for a long period and then converted into syrups. The methods were: cold sterilisation (Seitz E.K. filtered); pulp filtration and pasteurisation at 165°F. for half-an-hour; pulp filtration and 200 p.p.m. SO_2; clarification plus 200 p.p.m. SO_2, and

the acidity raised to 5% citric acid. After 12 months, strawberry and cherry flavours had disappeared, but loganberry and raspberry characters still persisted in satisfactory intensity.

3. In experiments where the sugar concentrations of syrups were varied, the retention of true fruit flavour increased as the sugar concentration was raised. Strawberry syrups with 30% sugar were particularly liable to lose their fruit character, but similar loganberry syrups remained much fresher in flavour after storage.

4. SO_2 and benzoic acid were compared as preservatives for various types of fruit syrups. The former proved more efficient. Despite initial improvement in the flavour of strawberry syrups preserved with benzoic acid in comparison with those treated with SO_2 the former gradually lost their freshness and acquired a full, but rather flat character. Raspberry, loganberry and black currant syrups, preserved with benzoic acid retained a full fresh flavour during storage. Hydroxybenzoic esters were generally inefficient at a strength of 10 p.p.m.

   Pasteurisation of syrups at 165°F. for half-an-hour gave perfect freedom from fermentation, but caused a definite alteration in flavour.

Acknowledgment.

The writer wishes to acknowledge the valuable help given by Mr. L. G. Darch, B.Sc., Mr. R. C. Curtis, B.S.c., and Mr. N. P. Bridgwater, B.Sc., during the course of the experimental work described in this report.

REFERENCES.

(1) Charley, V. L. S. *Ann. Report, Long Ashton Res. Stn.*, p. 175, 1932.

(2) Charley, V. L. S. *Ann. Report, Long Ashton Res. Stn.*, p. 162, 1935.

(3) Charley, V. L. S. *Ann. Report, Long Ashton Res. Stn.*, p. 213, 1936.

(4) Cruess, W. V. *Commercial Fruit and Vegetable Products*, p. 252. (*Published by MacGraw-Hill*, 1924).

(5) Charley, V. L. S. *Ann. Report, Long Ashton Res. Stn.*, p. 192, 1935.

INVESTIGATIONS ON FRUIT PRODUCTS.

XII.—CHEMICAL CONSTITUENTS OF FRESH JUICES FROM SINGLE VARIETIES OF SOFT FRUITS, AND THE SUITABILITY OF THE JUICES FOR SYRUP MANUFACTURE.

PROGRESS REPORT.—II.

By **VERNON L. S. CHARLEY, R. C. CURTIS** and **V. E. SILLS.**

The first investigations in this series were carried out during the summer of 1936, and the results published, as a Progress Report, in the Annual Report for that year (*Long Ashton Ann. Rept.*, p. 107, 1936). It has been considered desirable to publish the results of the 1937 investigations on account of the number of enquiries received relating to the suitability of certain varieties for syrup production, and because a number of interesting varieties were included for the first time in the 1937 season.

The experimental procedure in 1937 was identical to that previously described for 1936. The whole of the fruit was obtained from the single variety trial plots at the Research Station. In cases where a variety was examined both in 1936 and 1937, the fruits were taken from the same bushes in each year. Syrups with natural acidities less than 1.1% by weight (calculated as citric acid) were treated with citric acid to reach this figure. The SO_2 was raised to 300 p.p.m.

Results.

The detailed results are given in Table I.

TABLE I.

ANALYSES OF SINGLE VARIETY FRUIT JUICES AND CHARACTERS OF SYRUPS MADE THEREFROM.

Fruit.	Variety.	Date of Milling.	*Chemical Data for Juices.*					*Characters of Syrups.*	
			Specific Gravity.	*Acidity as Citric Acid per cent.*	*"Tannin" per cent.*	*Ash per cent.*	*Ascorbic Acid mgs./ 100 c.c.*	*Aroma.*	*Flavour.*
Strawberry	Madame Lefebvre	23/6/37	1.028	0.99	0.13	0.452	55.5	Slight, and not characteristic.	Flat and lacking in fruity character.
	Early Cambridge	29/6/37	1.040	1.03	0.11	0.461	65.3	Full and fruity.	Remarkably full and true to fruit. The best strawberry syrup yet tested.
Raspberry	Western Queen	30/6/37	1.033	0.79	0.11	0.338	71.8	Fairly intense. Clean and fruity.	Very fresh, clean flavour.
	Royal Sovereign	1/7/37	1.036	0.82	0.12	0.347	58.3	Weak.	Disappointing. Not fruity.
	Huxley	1/7/37	1.027	0.70	0.11	0.286	53.2	Good aroma.	Only fair. Lacking character.
	Tardive de Leopold	1/7/37	1.030	0.78	0.11	0.322	39.0	,, ,,	,, ,, ,, ,,
	Oberschlesien	2/7/37	1.026	0.72	0.13	0.289	66.5	Weak.	,, ,, ,, ,,
	Lloyd George	9/7/37	1.033	1.74	0.11	0.492	19.4	Least intense of series. Not fruity.	Disappointing. Not a clean fruit flavour.
	Bath Perfection	14/7/37	1.032	1.55	0.12	0.456	26.1	Good aroma of the fresh fruit.	Attractive but weak.
	Viking	14/7/37	1.032	1.51	0.12	0.390	29.0	,, ,, ,,	,, ,,
	Improved Beehive	14/7/37	1.032	1.68	0.12	0.374	31.9	,, ,, ,,	Full, fresh flavour.
	Norfolk Giant	14/7/37	1.032	2.22	0.14	0.430	37.7	Fair.	Flat and uninteresting.
	Preussen	17/7/37	1.030	1.17	0.10	0.452	21.8	Very intense aroma, but not of the fresh fruit.	Slightly fermented taste, but full fruit flavour.
Loganberry	Red Cross	14/7/37	1.032	1.41	0.10	0.349	27.6	Very good.	Very full attractive flavour.
	Baumforth A	14/7/37	1.032	1.43	0.14	—	30.5	,, ,,	,, ,, ,,
	—	14/7/37	1.039	2.73	0.19	0.359	26.1	Full and true to fresh fruit.	Very good.
Black currant	Mendip Cross	14/7/37	—	3.16	0.25	0.640	217.0	Peculiar aroma, not true to fruit.	Not true to fruit or intensely flavoured.
	Seabrook	16/7/37	—	2.82	0.37	—	178.0	Full and very attractive.	Very fine fruit flavour.
	Cotswold Cross	16/7/37	—	2.28	0.24	—	215.0	Weak.	Weak fruit flavour.
	Westwick Choice	16/7/37	—	2.32	0.25	—	223.0	,,	True to fruit, but weak.
	Boskoop	16/7/37	—	2.59	0.25	—	193.0	Fair aroma. True but not intense.	Very fine flavour. Best of the series.
	Edina	20/7/37	—	2.34	0.21	0.616	135.0	Full, intense aroma.	Slight "off" taste.
	Blacksmith	21/7/37	—	3.37	0.26	0.589	197.0	Weak.	,, ,,
	Davison's Eight	21/7/37	—	3.28	0.27	0.705	177.0	Full and clean.	Very fine flavour.
	Baldwin	21/7/37	—	3.14	0.25	0.636	209.0	Fair.	Not intense, or characteristic.
	Tinker	22/7/37	—	3.82	0.29	0.644	195.0	,,	Good flavour. Full and fresh.
	Wellington	22/7/37	—	3.30	0.27	0.679	174.0	Weak.	,, ,, ,,
	Black Tony	22/7/37	—	2.99	0.27	0.592	179.0	Fair.	True and clean, but weak.
Gooseberry	Colossal	26/7/37	1.042	1.84	0.08	0.304	20.3	No significant difference existed in the aroma or flavour of the syrups. The flavours were fruity without being characteristic of the gooseberry.	
	May Duke	26/7/37	1.040	2.06	0.09	0.280	32.3		
	Leveller	26/7/37	1.030	1.58	0.07	0.295	27.3		
	Whinham's Industry	27/7/37	1.036	1.88	0.09	0.336	29.9		
	Leader	27/7/37	1.037	1.25	0.07	0.272	28.6		
	Lancashire Lad	27/7/37	1.034	1.59	0.08	0.245	29.6		
	Drill	27/7/37	1.032	1.35	0.07	0.222	27.8		
	White smith	27/7/37	—	—	—	0.258	28.6		
	Careless	30/7/37	1.030	1.18	0.07	—	36.4		
	Lancer	28/7/37	1.036	1.27	0.06	0.262	26.0		
	Crown Bob	28/7/37	1.036	1.80	0.10	0.295	27.0		
	White Lion	28/7/37	1.035	1.28	0.07	0.290	28.6		

Discussion.

Chemical Data.

The fruit was milled before fermentation commenced and consequently the specific gravities represent the true figures for the various samples of fruit. The most interesting gravity was that of the Early Cambridge strawberry juice—a remarkable variety in other respects also. The acidities varied considerably from the corresponding figures in the previous year, but there was no definite relationship between the two series of figures. The "tannin" data in general showed only a slight variation from those for the 1936 juice, but it is interesting to note that the juice of Edina black currants showed a "tannin" content of 0.46% in 1936, and only 0.21% in 1937—this being one of the largest differences for any given item in the analyses from season to season.

The ascorbic acid values are remarkable for the high figures obtained for black currants. The average figures obtained for the two seasons are tabulated below, the figures in brackets referring to the 1936 series.

TABLE II.

Ascorbic Acid Values.

Fruit.	*Number of Varieties Examined.*	*Ascorbic Acid mgs./100 cc. juice. Mean Values.*
Strawberry	7 (3)	58.5 (52.0)
Raspberry	8 (8)	28.0 (26.3)
Loganberry	1 (0)	26.1 (—)
Black currant	12 (6)	190 (143.5)
Gooseberry	12 (3)	28.5 (27.3)

Some of the increases are not significant, but the figures for black currants are the highest yet obtained. The increase recorded for ascorbic acid content in the black currant series was considerable, and an appreciable increase was also noted in the strawberries. The values for raspberries and gooseberries showed only very slight differences for the two seasons. No record has been found in the literature of an ascorbic acid content for a single variety fruit juice higher than that reported here for Westwick Choice (223 mgs./100 cc.), or for mixed varieties higher than 190 mgs./cc. as reported for black currants. The black currant variety with the highest ascorbic acid value in 1936 was Baldwin, and this again contained a relatively high content of this constituent. In 1937, however, Westwick Choice, Mendip Cross and Cotswold Cross were all richer than Baldwin in the vitamin. These two latter varieties have been developed during the Long Ashton plant breeding programme. In both seasons Edina had the lowest ascorbic acid content among the black currants.

With only two years' results available it is premature to attempt to explain the increase in ascorbic acid by reference to any particular factor or set of factors, but details of weather conditions and cultural treatment are being carefully kept in order that an attempt may be made, after a number of seasons, to determine the causes influencing some of the chemical constituents in the juice.

Characters of Syrups made from Single Variety Juices.

Strawberry. Royal Sovereign, which although it had been the best syrup in 1936, was definitely lacking in fruit character in the present series. Early Cambridge, however, provided the finest strawberry syrup that has yet been encountered in the investigations at Long Ashton. It retained a full aroma, very clean and true to the fruit, but the most attractive feature of the syrup was the full, fresh fruit flavour, which was both intense and lasting.

Apart from Western Queen the other syrups were lacking in fruit character, although the aroma was satisfactory in most cases.

Raspberry. Lloyd George was far from being the best of the raspberry series in 1937, for the syrup lacked a sufficiently intense true fruit character. Improved Beehive and Preussen, both of which in 1936 possessed very scented aromas, were similarly scented in 1937. Red Cross and Baumforth A. were the best all-round syrups, and these were attractive on account of their completely unspoilt fresh fruit flavour.

Loganberry. The only sample included was made from a large bulk of berries grown at the Research Station. Loganberry syrups which have been correctly processed are easily distinguished from raspberry by their more subtle flavour, and the syrup in question was completely different from any in the preceding series.

Black Currant. The syrups in this series were, on the whole, an improvement on last year's products, and were characterised by fruity aromas and flavours. Boskoop was undoubtedly the finest syrup, whilst Davison's Eight and Seabrook (French) followed closely. The other syrups were deficient either in the natures or intensities of the flavours. Baldwin, which is one of the chief commercial varieties, was only fair in character both in 1936 and 1937.

Gooseberry. This series yielded no varietal differences of any significance. All the syrups were of a practically uniform character, and in many cases were almost completely lacking in any fruit flavour. The syrup from Drill was spoilt by a slightly unpleasant aftertaste. The syrups were all tested under code numbers. Three syrups from the previous year, namely, May Duke, Lancashire Lad and Gautrey's Earliest were included in the 1937 series of syrups. Beside their characteristic red colour, these three samples were distinguishable by their much lower acidities, and somewhat fuller and heavier flavours. In no case, however, was it possible to detect any flavour of the fruit itself. This cannot be taken as constituting a serious criticism of the syrups, as the natural flavour of the fruit is not intense nor does it possess a definite and prominent character.

Summary.

1. Data are given for some chemical constituents of a number of juices from single varieties of strawberries, raspberries, loganberries, black currants and gooseberries. Values were obtained similar to those for 1936, with the exception of those for ascorbic acid contents of black currant juices. These values showed a very considerable increase on the 1936 syrups. The average value for all the black currant juices was 190 mgs./100cc., the highest value being obtained for Westwick Choice juice, which contained 223 mgs./100 cc.

Among strawberries, Early Cambridge was the finest syrup that has yet been tested, whilst Royal Sovereign was disappointing. Of the raspberry varieties, Lloyd George produced a syrup of poor quality, and Red Cross and Baumforth A yielded the best products. In the black currant series, Boskoop, Davison's Eight and French made the most attractive syrups.

The gooseberry syrups were all similar in character and lacked definite fruit character.

INVESTIGATIONS ON FRUIT PRODUCTS.

XIII.—THE COMMERCIAL PRODUCTION OF FRUIT SYRUPS—SEASON 1937.

By VERNON L. S. CHARLEY.

The full details of the first year's commercial production of pure fruit syrups according to the Long Ashton method were given in the Annual Report for 1936 (page 213). The purpose of the present short progress report is to draw attention to a point of interest concerning a variation in procedure which arose during the making season of June—August 1937.

The observations deal with the prevention and effects of fermentation during the initial stages of processing.

Prevention of fermentation during processing.

At the commencement of the first season's work at the Ashton Gate syrup factory, the initial processing to remove the pectin from the fruit involved a slight controlled fermentation. Later in the season, however, an enzyme material was added to the milled fruit, and although slight fermentation still occurred in most cases during the enzyme action, it seldom became appreciable. The syrups made by either of these methods were constantly examined throughout the following winter and spring, and it appeared that where fermentation during the processing had become at all excessive, the fresh fruit flavour of the syrup was deficient, and in many cases there were signs of acetic taints due to the slow conversion of the alcohol into acetic acid. The taints became especially noticeable in milk shakes, to which the syrups imparted a sour taste.

Consequently in the 1937 season, it was decided to attempt to effect as complete a suppression as possible of fermentation throughout the processing. The various points that arose are discussed under the respective fruits.

Strawberry. In the 1936 season fermentation commenced rapidly and a drop in gravity of about 8—10 points occurred after 24 hours. In some cases the fermentation was even more rapid, and the suppression of fermentation became very difficult. In 1937, the enzyme action usually needed only 16 hours for completion and in very few cases was any fermentation noticeable during this period. The fruit used arrived in a remarkably sound condition from Wisbech by an overnight road journey of 12 hours, and no cases of active fermentation in the fruit on arrival were noted. On two occasions, however, the milled fruit appeared likely to ferment and 100 p.p.m. of SO_2 was added. This effectively suppressed the fermentation for the period of the enzyme action, and the SO_2 did not substantially retard the pectin decomposition.

Black Currant. This fruit showed certain differences from the behaviour of the other fruits which are difficult to explain. In the 1936 season, the black currants were purchased from the Long Ashton Research Station plantations, and high-class fruit in sound condition was supplied. The greatest difficulty was experienced in removing the pectin. A slight fermentation occurred during 3—5 days that the milled fruit was in contact with the enzyme in 600 gallons tanks. In the 1937 season the fruit was purchased from the same source and appeared to be in the same condition and of similar quality, but fermentation in the milled fruit commenced almost immediately. The yeasts were immediately suppressed by the addition of 400 p.p.m. of SO_2 to the milled fruit and the dose of enzyme was increased to 1¼ lbs. per 100 gallons of fruit.

Raspberry. In view of the difficulty of processing large quantities of black currants and raspberries simultaneously, it was decided to purchase Scotch raspberries which would not mature until the beginning of August, by which time the black currant programme would be completed.

The experience gained in the first season indicated that the complete suppression of fermentation in raspberries travelling from Scotland would be exceedingly difficult. The alcohol contents of the juice of fruits arriving from Scotland in that year in many cases exceeded 1% by weight, and reached 1.28% in one particular consignment of 5 tons. Accordingly, in 1937, the writer visited the Blairgowrie area of Scotland at the beginning of August in order to gain personal experience of the conditions under which the berries were picked, preserved and despatched to Bristol, and also to carry out some experiments dealing with the prevention of fermentation.

The weather at the commencement of August was very hot and dry. Ten tons of raspberries were bought and put in 1 cwt. tubs. The fruit was then treated by the writer with 200 p.p.m. of SO_2 (in the form of 5% sulphurous acid) and 0.1% pectinol. The intimate mixing of the SO_2 and enzyme into the fruit was not easy, on account of the method of picking adopted. The canes are planted in very long rows, and the pickers, mostly gipsies, are given buckets of about 1½ gallons capacity, into which the berries are picked. In view of the loss of time caused by too frequent visits to the weighing hut, the pickers press the fruit down hard in the buckets, so that when the contents are emptied into the tubs, the fruit mass retains the exact shape of the bucket and does not break up. In treating the fruits with SO_2 it is essential for these large masses of raspberries to be disintegrated so that the preservative can gain access to all the tissues. A vigorous beating of the fruit with a special form of "paddle," used in Scotland for pulping raspberries, enabled a thorough mixing to be ensured. The fruit was despatched in one consignment to Bristol by road, and the writer travelled ahead to examine the condition of the fruit on arrival.

It was obvious that 200 p.p.m. of SO_2 had been insufficient to prevent considerable fermentation under the conditions of the experiment. There was very considerable separation of juice from fruit tissue and, when the tubs were emptied into a large vat, separation on a large scale quickly followed. The bulked juice from the treated raspberries contained 1.38% alcohol by weight, whilst that from one ton of untreated fruit contained 1.68%. The SO_2 had thus exerted only a very slight effect on the yeasts.

By telephoning instructions to the Scottish agents, further tests were carried out using a number of higher strengths of SO_2, and eventually it was found that 600 p.p.m. of SO_2 were necessary to prevent any fermentation whatever in fruit picked and despatched under the conditions mentioned above. In these circumstances the enzyme treatment had not been completed by the time the fruit arrived at the factory, and a further twelve hours appeared to be necessary to overcome the effect of the higher SO_2 content of the fruit.

The presence of 600 p.p.m. of SO_2 in the fruit for 24 hours was not prejudicial to later processing. Although most of the SO_2 was present in the juice and did not remain in the press cake, there were considerable losses during pressing and centrifuging, and further preservative generally had to be added to the finished syrups to raise the SO_2 content to 350 p.p.m.

Characters of the syrups.

Flavour. The result of the suppression of fermentation on syrup flavour was encouraging. The flavours of the syrups, both immediately after production and six months later, were fresher and more characteristic of the fruit than the previous season's material in which fermentation had occurred. It is claimed that the true, characteristic, fresh flavour of the black currant itself is obtained in the syrup only if fermentation is prevented. The very slight fermentation occurring in 1936 caused a definite change in flavour which was detrimental to the product.

The raspberry syrup made without preliminary fermentation retained the " straight " fruit flavour, but when fermentation was allowed to develop the flavour became mixed with subsidiary tastes and was difficult to distinguish from the loganberry. In raspberry syrups, fermentation appeared to introduce a " cooked " taste similar to that of the jam. This effect was even more strongly marked in the case of the strawberry syrups.

Stability. The experiments showed clearly that when fermentation was allowed to proceed to any extent in the fruit material, the subsequent prevention of fermentation during long term storage of the syrup became correspondingly more difficult.

Summary.

The occurrence of fermentation in soft fruits either during transit to the factory or during the initial stage of processing has been shown to cause an alteration in flavour of the finished syrup. The complete absence of fermentation enables syrups to be produced with fresher fruit flavours than when even slight fermentation occurs. This is particularly the case with strawberries and raspberries. Fermentation in strawberries is prevented by the addition of 100 p.p.m. of SO_2, but raspberries despatched in cwt. tubs from Scotland to Bristol needed 600 p.p.m. of SO_2 to suppress yeast action.

Acknowledgment.

The writer wishes to record his appreciation of the help afforded him by the Directors of Messrs. H. W. Carter & Co., The Old Refinery, Bristol, and for their permission to publish this report.

INVESTIGATIONS ON FRUIT PRODUCTS.

XIV.—EXPERIMENTS ON THE PRODUCTION OF UNFERMENTED APPLE JUICE, 1934-38.*

By VERNON L. S. CHARLEY.

The unfermented apple juice industry in Europe which commenced to develop rapidly about 12 years ago has made extraordinary advances during the last 5 years. The German and Swiss production of this beverage has increased to a remarkable extent, and it is stated that the output and consumption of apple juice in Germany in 1937 was between 13-16 million gallons. The increase in consumption in Switzerland and Austria has also been significant, and reports from the Scandinavian countries indicate that the modern tendency towards unfermented drinks is apparent in these countries also.

Some idea of the importance attached to the new industry on the Continent is shown by the fact that an International Conference was held in Berlin in August 1937 to discuss all aspects of the industry. Consideration was given to such questions as technical processes for production and storage, marketing, legal regulations, propaganda, sales methods and health-giving properties of various fruit juices, with special reference throughout to the case of apple juice.

No attempt is made here to give any outline of the information obtained at the Conference, as a full report has been prepared by the Conference Authorities. Reference, however, is made later in this Report both to certain Continental processes which were discussed in Berlin, and to observations made by the writer when studying the cider and unfermented apple juice industries in Germany in September 1935.

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* Some results obtained during the period January—March 1938 are included in this paper for the sake of completeness. It was possible to include them as they were available before going to press.

Although the subject of non-alcoholic apple juice has been examined at Long Ashton for several seasons, it has not been considered advisable to publish any data in addition to the report on the preliminary experiments which was included in the Annual Report of the Research Station for 1932 (page 214). Various aspects of the problem have been investigated and since much interest is being shown by a considerable number of fruit growers—either individually or as Associations—and by various producers of fruit beverages, it has been decided to present in this report all the relative data that have been obtained during the past 3 years. Many of the investigations have not yet been carried to a point of commercial application, but the results so far obtained are given so that prospective manufacturers of apple juice may obtain the available information on the character of English apple drinks, and appreciate some of the difficulties that arise in their production, storage and marketing.

The experiments reported deal with the following points :—The flavour and stability of a number of cider and culinary apple juices preserved by the cold sterilisation and hot pasteurisation processes ; the storage of cold-filtered juice in various wooden and metallic containers ; the deaeration and flash pasteurisation treatments for stabilisation of flavour and prevention of fermentation in canned and bottled juices.

The report is divided into the following four sections :—

A. Hot and cold processing of cider and culinary apple juices.
    (*a*) 1935 season.
    (*b*) 1936 season.

B. Effect of pasteurising temperature on flavour and stability of juices with different acidities.

C. Storage of cold-processed apple juice in wooden and metal vessels.

D. Experiments on the deaeration and flash pasteurisation of apple juices for immediate canning or bottling.

A. HOT AND COLD PROCESSING OF CIDER AND CULINARY APPLE JUICES.

(a) 1935 Experiments.

The details of the materials used, treatments and results are summarised in Table I. and detailed observations on stability of the

TABLE I.

STABILITY AND FLAVOUR OF 1935 SEASON APPLE JUICES BOTTLED BY HOT AND COLD PROCESSES.

No.	*Juice or Blend of Juices.*	*Specific Gravity.*	*Acidity. Malic Acid per cent.*	*"Tannin" per cent.*	*Method of Bottling and Stabilisation.*	*Stability of Bottled Juices During 12 Months Storage.*	*Flavour of Juices (previous to changes indicated in last column).*
1	Mixed Somerset cider fruit ..	1.034	0.67	0.20	Carbonated : cold*	Sound for 2 months : slight fermentation later : variable in bottles.	Brisk : clean and fruity.
	do. do.				Still : cold.	Needed refiltration : subsequently slight fermentation.	do. do.
	do. do.				Still : pasteurised.	Clear : no deposit or fermentation.	More palatable than other juices : less acid.
4	1 Bittersweet : 4 Bramley ..	1.039	0.70	0.15	Carbonated : cold.	Variable : many bottles burst.	Very brisk and rather thin.
	do. do.				Still cold.	Considerable fermentation after bottling : sound after refiltration.	do. do.
	do. do.				Still : pasteurised.	Sound : slight flocculent deposit.	Heavier flavour with definite "cooked" taste.
5	1 Bittersweet : 1 Bramley ..	1.041	0.71	0.17	Carbonated : cold.	Sound for 2 months, then gradually developed much fermentation.	Very much fuller than No. 4 : attractive.
	do. do.				Still : cold.	Fermented rapidly : variable after refiltration.	do. do.
	do. do.				Still : pasteurised.	Sound : no deposit or fermentation: juice brilliant.	Full-bodied and only slight "cooked" flavour.
6	1 Bittersweet : 4 Bramley : 1 water	1.040	0.69	0.14	Still : cold.	Fermented rapidly : sound after filtration.	Thin and sharp, but clean apple character.
	do. do. do.				Still : pasteurised.	Brilliant juice with no deposit or fermentation.	Fuller flavour, but not so attractive
7	1 Bittersweet : 4 Bramley : 1 water	1.040	0.67	0.12	Still : cold.	90% bottles sound : rest sound after filtration.	Weak flavour : not attractive.
	do. do. do.				Still : pasteurised.	Brilliant juice : very faint deposit.	do. do.
8	2 Bittersweet : 2 Bramley : 1 water	1.039	0.71	0.15	Still : cold.	Slight fermentation : sound after filtration.	Fair flavour : apple character lacking.
	do. do. do.				Still : pasteurised.	Clear : no deposit.	do. do.
9	1 Bittersweet : 1 Bramley : 1 water	1.039	0.71	0.12	Still : cold.	Variable fermentation which was renewed after refiltration.	Weak flavour.
	do. do. do.				Still : pasteurised.	Brilliant and no deposit : slight mould growth in a few bottles.	do.
10	1 Bittersweet : 4 Bramley : 5 water	1.022	0.57	0.11	Still : cold.	Mould growth only : sound after refiltration.	Very weak flavour : no apple character.
	do. do. do.				Still : pasteurised.	Brilliant : no deposit.	do. do.
13	5 Kingston Black : 1 water ..	1.042	0.72	0.19	Carbonated : cold.	Fermentation developed after 2 months.	Full and strong cider apple flavour : very attractive.
	do. do.				Still : cold.	Fermentation developed after 2 months : sound after refiltration.	do. do.
	do. do.				Still : pasteurised.	Brilliant juice : no deposit.	Clean and heavy fruit flavour: slightly "cooked."
14	Kingston Black (undiluted) ..	1.050	0.68	0.22	Still : cold.	Fermentation developed after 2 months : perfect stability after refiltration.	Heavy flavour.
	do. do.				Still : pasteurised.	Sound.	Very heavy flavour.
15A	Newton Wonder	1.042	0.71	0.13	Still : cold.	No fermentation developed during 12 months : slight mould growth.	Attractive fruit character.
	do.				Still : pasteurised.	Clear : sound.	Pleasant full flavoured juice.
15B	Bramley's Seedling	1.042	0.77	0.11	Still : cold.	Sound, except for slight mould.	Thin and very sharp.
	do.				Still : pasteurised.	Sound : brilliant juice.	do. do.
15C	King of the Pippins	1.040	0.71	0.12	Still : cold.	Sound : very slight flocculent deposit.	Fair flavour : slight apple character.
	do. do.				Still : pasteurised.	Sound : brilliant juice.	do. definite "cooked" taste.

* Cold indicates sterilisation by filtration method.

cold processed juices are set out in Table II. A number of apple juices from cider, culinary and dessert varieties were treated separately, or as various blends, by the cold sterilisation and pasteurisation methods. The experiments were carried out during the week commencing November 25th, 1935. The temperature of the juices was about 3°C. throughout the preliminary processing. In order that the fruit flavours of the various juices could be more accurately assessed, it was decided to adjust the specific gravity and acidity of most of the juices to approximately 1.040 and 0.70% respectively. This was done by the addition of water in the case of juices with gravities above 1.040, and of a strong solution of citric acid where acidities below 0.7% were encountered. In the case of Bramley's Seedling juice, the addition of water effected the necessary reduction of gravity and acidity. The analyses of the fresh juices before adjustment were as follows :—

Fruit.	*Specific Gravity.*	*Acidity* (%)	*Tannin* (%)
Mixed Cider Varieties	1.042	0.36	0.21
,, ,, Bittersweet Varieties	1.041	0.20	0.19
Bramley's Seedling	1.045	0.94	0.12
Kingston Black	1.058	0.68	0.22
Newton Wonder	1.052	0.57	0.14
King of the Pippin	1.051	0.53	0.13

The juices were allowed to commence a very slight fermentation, which usually started after 1 or 2 days in the case of the culinary juices, thus demonstrating the extremely fermentable nature of this particular type of juice. A pulp filter was used to clarify the cloudy juice to a brilliant condition. A portion of this juice was then filled into bottles and pasteurised at 165°F. for half-an-hour, the bottles being removed from the hot water at the end of the required period. The remainder of the brilliant juice was filtered through a Seitz filter in which E.K. discs had been fitted. The filter had been thoroughly sterilised by steam, and the method of using it was in every respect as recommended by the makers. The bottles were washed in the usual way for cider bottles. Champagne pint and quart bottles were used. These were soaked in a suitable detergent solution at 150°F. for 20 minutes followed by a rinsing with jets of cold water. Finally the bottles were treated with 2% SO_2 solution on the Seitz wheel. They were allowed to drain neck downwards on a rack for one minute, and filled with Seitz-filtered juice from the appropriate outlet of the filter. A spherical fitment surrounding the outlet prevented the access of micro-organisms to the bottle, and the sterility of this fitment was ensured by frequent moistening with 2% SO_2. The corks were gently softened with warm water and then sterilised with 2% SO_2 until needed for use. After filling and corking, the bottles were laid on their sides and stored in a cellar, the temperature of which varied between 3—8°C.

General Flavour Characters of the Juices.

The mixed cider fruit and Kingston Black juices were included in the scheme to enable a comparison to be made of these with the juices from culinary sorts. The flavours of these various types of juices, where they were treated by a similar process, were in accordance with expectations. The Kingston Black juices were fully flavoured, with a very definite cider character. The undiluted juice was a remarkable product, possessing a rich, luscious taste, which was unequalled by any other juice. The mixed cider fruit juice was less aromatic, but represented a full and brisk beverage that was quite attractive. The unblended Bramley's Seedling juice (15B) was thin, and, quite apart from the excessively penetrating acidity, the juice suffered from a lack of apple flavour that made it definitely unattractive. The blends of bittersweet and Bramley's Seedling juices (4 and 5) combined the qualities of the two constituents, but it was necessary to use equal quantities of the two types of fruit to obtain a really satisfactory mellowing of the Bramley's character. Although the acidity values of the blends are shown by Table I to be practically constant, it was noticed that the presence of Bramley's juice in a blend was always associated with an excessive sharpness, indicating that this fruit possessed an unusually penetrating type of acidity. The juices from Nos. 6, 7, 8, were included to determine whether there was any possibility of using blends of apple juices as a basis for a somewhat diluted product, or for a less sweet type of drink (9 and 10). The observations made on the finished beverages indicate that dilution to any appreciable extent is quite impossible if an attractively flavoured apple drink is required.

Effect of Type of Process on Flavour.

The main difference between the hot and the cold processed juices was very marked, and was noticeable in all the drinks. The cold processed product possessed a less intense aroma and the flavour was weaker than in the pasteurised samples. The acidity also tended to be more noticeable and the " body " of the juices was deficient when compared directly with the heat treated samples. The differences, however, were not all in favour of the pasteurised series. Trueness and freshness of flavour were specifically considered in tasting, and it was obvious that the cold process had yielded juices in which the fresh juice characters were relatively unchanged, whereas the application of heat had reduced the freshness of the flavour, and converted a rather thin but fruity juice into a fuller but somewhat "cooked" drink. It is thus seen that juices made by either process combine one satisfactory and one unsatisfactory character. This point is discussed in more detail later in the report.

The carbonated drinks made by the cold process were not greatly superior to the "still" juices. This is probably due to the fact that the sugar-acid ratio was suitable to afford the necessary degree of briskness, thus eliminating the need for aeration.

Stability of Juices.

The observations made on the stability of juices are given in general terms in Table I. It will be seen that much trouble was experienced with fermentation in the cold processed juices, but not with the pasteurised samples. The pasteurisation treatment in no case affected the clarity of the juice, and complete sterility of the product was achieved. On the other hand, the results of the cold processing were much less satisfactory. In order to indicate more clearly the early stages of the development of micro-organisms in the juice, the full observations for the cold processed juices in the series under consideration have been set out in Table II. The following points arise :—

(i) Carbonated juices remained free from fermentation or bacterial activity for a considerable period after the still juices had shown signs of yeast development. The pressure of CO_2 in cider has always been regarded as a mild form of yeast inhibitor, but the present series of trials show that a definite degree of stability was imparted to apple juices for a period of over 2 months by carbonation at a pressure of 30 lbs. per square inch. No details of the behaviour of carbonated juices after fermentation and refiltration are available, for the scale of the experiments precluded the further treatment of these samples.

(ii) The development of fermentation was irregular in all the bulks of bottled juices. In some cases, the unsound bottles would account for only a small percentage of

TABLE II.

STABILITY OF BOTTLED COLD STERILISED APPLE JUICES.
1935 SEASON.

No.	Juice or Blend.	Still (S) or Carbonated (C)	CONDITION OF BOTTLED JUICES (STORED AT 10°—14°C.)			
			After 10 *Days in Bottle.*	15 *Days.*	3 *Months.*	12 *Months.*
1	Mixed cider juice .. .	C	All bottles clear and sound.	*All bottles clear and sound.	Quarts sound : 50% pints clear.	Quarts sound : pints mostly with slight yeast.
	do. do.	S	Yeasts and moulds in all bottles.	Bad yeast deposits.	Bad yeast deposits in most bottles.	Bad yeast deposits.
4	1 Bittersweet : 4 Bramley .	C	All sound.	*All sound.	All sound.	Very variable : many bottles clear, many burst.
	do. do. ..	S	Very bad yeasts and mould growths.	Very bad condition : 30% bottles clear.	Sound.	Sound.
5	1 Bittersweet : 1 Bramley ..	C	All sound.	*All sound except few nips with yeast.	Bad yeast in 90% : bottles : rest sound.	As before.
	do. do. ..	S	All bottles contained much yeast and pectin deposit	*All bottles with yeast and pectin deposit.	Most sound : some bad yeast.	Very variable : 50% sound.
6	1 Bittersweet : 4 Bramley : 1 water	S	Very slight deposit : no yeast.	*Pints mostly sound : quarts and nips variable : moulds present.	Sound.	All sound : no deposit.
7	1 Bittersweet : 4 Bramley : 2 water	S	do. do.	*Moulds in all nips : rest 95% sound.	Sound.	do. do.
8	2 Bittersweet : 2 Bramley : 1 water	S	Sound quarts and pints : deposits in nips.	* do. do.	Sound.	do. do.
9	1 Bittersweet : 1 Bramley : 1 water	S	do. do.	* do. do.	Sound.	Variable : pints perfect : nips some slight mould.
10	1 Bittersweet : 4 Bramley : 5 water	S	do. do.	*Very slight mould infection in all bottles.	Sound.	All sound. No deposit.
13	5 Kingston Black : 1 water ..	C	All sound.	All sound.	50% bottles with bad yeast deposit.	Very variable : many sound.
	do. do. ..	S	Slight trace of yeast deposit.	Very bad condition : variable condition in bottles.	Sound.	Sound.
14	Kingston Black	S	Slight mould growth.	Slight mould growth in all pints.	As previously.	As before.
15B	Bramley's Seedling	S	All sound.	All sound.	Sound.	Very slight mould in all bottles.

* Indicates Refiltration through E.K. Discs after the 15 day period.

the total, whilst in other cases the reverse was the case. In most samples, however, it was possible to keep a number of bottles throughout the whole twelve months without deterioration, and this fact, together with the irregularity noted above, appeared to throw suspicion for the cause of fermentation on to the bottles themselves and to remove it from the sterilising filter. If the filter had delivered an unsterile juice it would be expected that fermentation would have developed in all bottles. In view of the above observations it appeared that the ordinary bottle washing and filling methods for cider are quite inadequate for apple juice.

(iii) The slight development of the moulds which appeared was notable. In the cases where this was noted, a few rosettes of white filaments were noted a week after bottling. In the case of Nos. 6—10 (Table II) the development quickly ceased, and only a few aggregates of a mould of the Mucor type were eventually present. After a second filtration, these juices remained free from further mould growth.

(iv) Although the observations in Table II indicate a very unsatisfactory state of stability, in only one case (No. 4) was the fermentation sufficient to cause a definite breakage in the bottles. It is significant that this juice contained a high proportion of culinary apple juice. The alcohol content in the juice at the time of bottle breakage was 0.8% by weight ; the juice had contained 0.3% when it was originally filtered into bottle ; the increase in alcohol during the storage in bottle represented a loss of specific gravity of 5 degrees.

(b) 1936 Experiments.

The 1935 experiments were repeated in 1936, but using other fruit and including enzyme treatment in some cases. The bottle washing treatment was very carefully considered before commencing the actual experiments. It was decided to subject the bottles to the action of live steam, and this was done by connecting the steam supply to the water entry of the rinsing jets in the bottle washing outfit. Very effective heating was thus achieved, although a larger number of bottles were broken than by the previous method. The steamed bottles were soaked at 155°F. for 20 minutes in a 0.5 detergent solution, rinsed, and run over the sulphuring wheel immediately before filling. The results are given in Table III, the chief points of interest being as follows :—

Flavour.

The results for Kingston Black and mixed cider fruit were similar to those for 1935. The juices were fully flavoured and very pleasant to drink. Special interest, however, attaches to the samples G—L, and M—P. The first series were made from a blend of equal quantities of Allington Pippin and Cox's Orange Pippin apples, whilst the last three juices were made from equal quantities of Knotted Kernel and Lane's Prince Albert. The juices were more fully flavoured than the 1935 series, but a slightly rough aftertaste was noticeable in several of the samples. This taste appears to be associated with culinary juice products and it has often been noticed that a persistent taste of this type is predominant when fermented ciders or wines are made from these types of juices. In the series of juices made in 1935, this harsh character was more noticeable on account of the smooth, pleasant character of the cider apple juices.

In the Kingston Black series, the pasteurised juice was much inferior to the Seitz filtered drink. The heated juice was fully flavoured, but possessed a very marked " cooked " taste. It was not refreshing and compared very unfavourably with the Seitz filtered juices which were clean, brisk and attractive.

When the varying effects of pasteurisation and Seitz filtration are considered in the light of the 1936 season juices, it appears that juices which originally possess a sufficiently full flavour react better to the cold process than those whose initial flavour is thin. These latter juices probably gain in attractiveness from pasteurisation.

Stability.

Despite the extra precautions that were taken to ensure sterility of bottles, considerable trouble was again experienced in all the cold processed samples. The occurrence of fermentation was not associated with mould growth, but its irregularity was again noted. In the case of samples A, H and P, samples of the Seitz filtered juice were taken straight from the outlet of the filter into sterile test tubes and examined by preparing plate cultures. In A and H no organisms were found, but several yeast colonies developed from sample P. In this series of experiments it again

TABLE III.

STABILITY AND FLAVOUR OF APPLE JUICES BOTTLED BY HOT AND COLD PROCESSES.

1936 SEASON.

No.	*Type of Fruit used.*	*Method of Stabilisation.*	*Carbonated (C) or Still (S)*	*Condition of bottled juices after 6 months.*	*Flavour of juices 1 mouth after bottling.*
A	Mixed cider	Sterile filtration.	S	†Considerable yeast deposit.	Full bodied and apple flavour.
B	do.	do.	C	do. do.	Brisker and more refreshing than A.
C	do.	Pasteurisation.	S	No deposit or fermentation : brilliant.	Full bodied : definite pasteurised taste.
D	Kingston Black	Sterile filtration	S	†Brilliant juice : 98% free from fermentation.	Very full and attractive.
E	do. do.	do.	C.	Quarts showed slight pectin deposit but no yeast : pints contained definite yeast.	Superior to D : remarkably smooth.
F	do. do.	Pasteurisation.	S	Very slight haze and faint deposit : no fermentation.	Heavy and inferior to D and E.
G*	Allington Pippin & Cox's Orange Pippin	do.	S	Clear : slight pectin deposit : yeast in few bottles.	Clean and fully flavoured : slight rough aftertaste.
H*	do. do. do.	Sterile filtration.	S	Bad yeast and pectin deposits.	Spoilt by fermentation.
J	do. do. do.	Pasteurisation.	S	Faint cloudiness : no fermentation.	Thin and much less flavour than G.
K	do. do. do.	Sterile filtration.	S	†Bad yeast deposit.	Rough aftertaste : otherwise satisfactory.
L	do. do. do.	do.	C	Clear : no deposit : slight signs of fermentation.	Cleaner and more attractive than K.
M*	Knotted Kernel & Lane's Prince Albert	do.	S	Bad yeast and pectin deposits.	Spoilt by fermentation.
N	do. do. do.	do.	S	†Variable : quarts perfect, some pints bad.	Fair flavour : slight rough aftertaste.
P	do. do. do.	do.	C	Bad yeast deposit.	Superior to N : very refreshing and pleasant.

† Indicates refiltration 2 months after bottling the juices.

* Indicates that no pectin-decomposing enzymes were used.

appeared that the exacting demands of the cold process for absolute sterility of bottles and bottling conditions had not been met.

The samples that remained free from fermentation also retained their clarity to a large extent. No fermentation occurred previous to stabilisation and bottling, but the use of an enzyme appeared to prevent the deposition of pectic material during the storage of the juices.

Commercial Possibilities.

Many difficulties arise when an attempt is made to assess the values of certain beverages for commercial purposes and several opinions are always obtained before making final decisions on such characters as aroma and flavour. Personal tastes show great variation and it is often impossible to obtain any measure of agreement among members of a small flavour panel. Consequently, with these products, it was decided to ascertain the public taste in the following way. The three samples D, E and F, were exhibited at the Long Ashton Annual Cider Tasting Day on May 6th, 1937, and visitors were invited to taste the juices and to give an opinion on their relative merits. The results were expressed numerically as follows : three points were awarded to the juice placed first, two to the second and one to the third. The results for 121 visitors were as follows :—

E.	Seitz filtered carbonated juice	141
D.	,, ,, still ,, ...	127
F.	Pasteurised juice	104

The figures show clearly that with this particular juice the general public favoured the cold processed aerated juice. Whether the same result would have been obtained with a culinary instead of a cider juice it is impossible to say, but it is hoped to extend the idea of obtaining an expression of opinion from large numbers of visitors in this way, in order to obtain an indication of the public taste.

B. EFFECT OF PASTEURISING TEMPERATURE ON FLAVOUR AND STABILITY OF JUICES WITH DIFFERENT ACIDITIES.

The unsatisfactory results of the 1935 experiments led to the extension of the 1936 programme to include a series of trials in which apple juices of different acidities were either cold sterilised or pasteurised, three different temperatures being tested for the latter procedure. A bulk of 240 gallons of a mixed cider juice (specific gravity 1.042, acidity 0.34%, tannin 0.18%) was used. Fermentation was allowed to proceed until 0.4% alcohol had been formed, when the juice was pulp filtered, and the acidity adjusted to the required figure by the addition of a strong solution of citric acid. A certain quantity from each bulk of juice of different acidity was passed through the sterilising filter, and received direct into bottles which had been treated in exactly the same way as described under (b) above. The remainder of the pulp filtered juice was filled into similarly treated bottles and pasteurised at the given temperature for 30 minutes. At the conclusion of the required period, the bottles were taken from the hot water and allowed to cool in the air.

The results of the experiments are given in Table IV.

Flavour.

The possibility of fermentation developing in the cold processed juices was foreseen and the flavours of all the juices were noted shortly after bottling.

The most attractive juice was that with 0.5% acidity. This was only Seitz filtered, and no pasteurised samples of this particular acidity were taken. The other observations show that whilst pasteurisation at 50°C. for 30 minutes resulted in a loss of freshness of flavour in the apple juice, this temperature did not always give absolute sterility. The juices of lower acidity developed considerable fermentation, but the highest acidity (0.77%) appeared to inhibit yeast activity. The intermediate temperature of 60°C. allowed a slight yeast growth in the juice with the lowest acidity, but the two juices of higher acidity were completely stabilised at this temperature. The highest temperature, 65°C., was very effective at all the acidities.

These experiments indicate that acidity exerts an inhibiting action on the yeasts, and thus the temperature of pasteurisation should be relatively high for low acid juices.

The influence of the varying pasteurising temperatures on flavour was most marked in the case of the most acid juice. The juices stabilised at 60°C. and 65°C. were definitely unpleasant, whereas the sample treated at 50°C. was only slightly inferior to the cold process juice. Similar effects, though not of the same magnitude, were noted with the juices of lower acidity, and it seems probable

TABLE IV.

EFFECT OF METHOD OF STABILISATION AND TEMPERATURE OF PASTEURISATION ON STABILITY AND FLAVOUR OF APPLE JUICES OF VARIOUS ACIDITIES.

No.	*Acidity as malic acid. Per cent.*	*Method of stabilisation.*	*Condition of bottled juices after 12 months.*	*Flavour of bottled juices after 2 months.*
A	0.43	Cold filtration.	Bad yeasts : slightly flocculent deposit.	Too sweet, but clean and fully flavoured.
B.1	0.44	do. do.	Very bad yeast deposit.	do. do. do.
B.2	do.	Pasteurised at 50°C.	Much yeast deposit : some mould.	Heavy flavour : not "cooked."
B.3	do.	do. at 60°C.	Very slight yeast deposit.	Very heavy flavour : only slight "cooked" taste.
B.4	do.	do. at 65°C.	No yeast : slight flocculent deposit.	Very heavy flavour : strong "cooked" taste.
C.	0.50	Cold filtration.	Bad yeast deposit.	Very pleasant juice.
D.1	0.57	do. do.	do. do.	Very pleasant juice : brisk and refreshing.
D.2	do.	Pasteurised at 50°C.	Much yeast and mould.	Slightly less fresh than D.1.
D.3	do.	do. at 60°C.	Clear : no deposit.	Heavier flavour than D.1.
D.4	do.	do. at 65°C.	do. do.	Definite "cooked" flavour.
E.	0.64	Cold filtration.	Bad yeast deposit.	Too sharp but very fresh and clean.
F.1	0.77	do. do.	do. do.	Much too sharp : thin flavour.
F.2	do.	Pasteurised at 50°C.	Sound : no deposit.	Less brisk than F.1.
F.3	do.	do. at 60°C.	Flocculent deposit : no fermentation.	Definite "cooked" taste : not attractive.
F.4	do.	do. at 65°C.	Very slight deposit : no fermentation.	Very noticeable "cooked" taste : unpleasant.

that the high acidities, in conjunction with the heat treatment, are responsible for the strongly cooked flavour acquired by this type of juice.

From the point of view of flavour retention, it is advisable not to exceed 60°C. for pasteurisation, and this temperature should not be exceeded unless there is definite evidence that it is too low to effect efficient sterilisation. This temperature, however, should suffice for the preservation of the majority of English apple juices.

C. STORAGE OF COLD-PROCESSED APPLE JUICES IN WOODEN AND METAL CONTAINERS.

During the Tour of English Cider-makers in Germany in 1935, it was noted that many factories utilised wood as a medium for storage of apple juice, although these wooden vessels were rapidly being superseded by the new Seitz-Boehi steel tank.

Since methods of storing large bulks of English apple juice had not been examined previously, experiments were carried out to test the suitabilities of various kinds of containers for this purpose. It is most unfortunate that it was impossible to arrange for the inclusion in the experiments of a Seitz-Boehi tank for comparison with the containers used. This form of storage has not yet been tested at Long Ashton on account of its relatively high cost.

The following types of vessels were used in the experiments :—

A, B, C, E. F.	Ordinary 30—40 gallon cider casks taken from stock.
G 1, G 3.	Old 30 gallon cider casks. Not in sound condition.
D, H, J.	35 gallon re-made beer casks. Very sound condition.
K, L.	Metal casks with lacquered lining.
M.	Stainless steel drum.

The method of using liquid SO_2 was similar to that adopted in Germany. Liquid SO_2 is measured into a glass gauge and is allowed to pass into the cask, which is then tightly closed. When the cask is needed for filling, the SO_2 is removed by solution in a small quantity of sterile water.

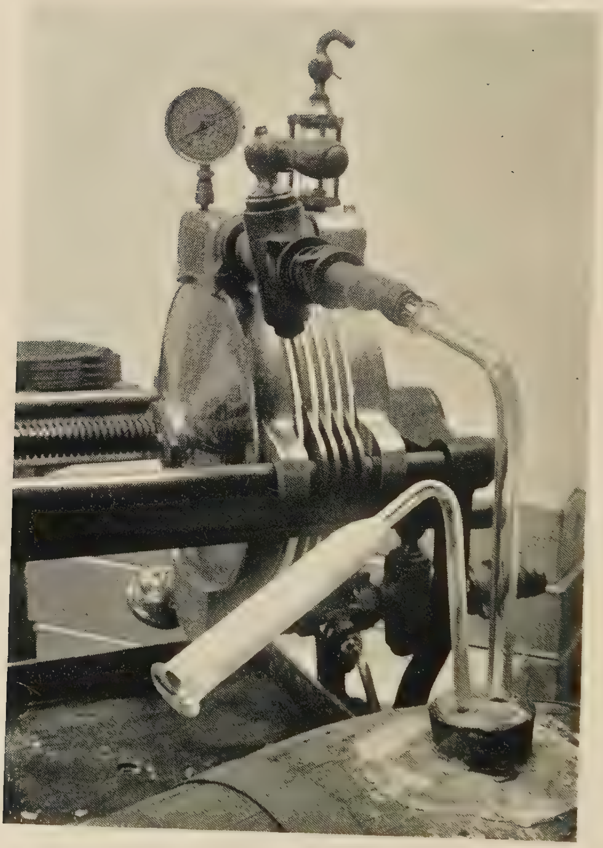


FIGURE I.

A large bulk of 550 gallons of a blend of 4 parts of Bramley's Seedling juice to 1 part of bittersweet juice was prepared. The gravity was allowed to fall 4 degrees, and the juice was pulp-filtered to a brilliant condition. The Seitz E.K. filtration was effected with ease, and the juice was led from the outlet of the filter into the cask by means of the special glass fitment illustrated in Fig. I.

The cork was tightly fitted into the container and immediately sealed in with molten paraffin wax. The escaping air was allowed to pass through a side tube which contained a roll of cotton wool soaked in alcohol. When a container was full, the cork was quickly removed and another sterilised cork, fitted with a fermentation lock, was inserted and pressed into position. The casks and metal vessels were removed to their storage position and the corks coated with paraffin wax.

The observations on the juices after 12 months in store are given in Table V.

Although no sign of fermentation was noted in any of the casks or metal vessels throughout the storage period, it was obvious when the juices were examined that considerable fermentation and mould growth had developed. Thick layers of green mould and vinegar plant covered the surface of some casks—although the flavours of the juices—or ciders—were not adversely affected.

In only one vessel was no fermentation apparent. This was a 10-gallon, lacquered steel cask, as used for the quick champagne process in France. Where wooden casks were used the best result was obtained with a Bottomley brown cask enamel lining together with calcium bisulphite treatment. A Stainless steel and a Dukeron lined cider cask were almost as satisfactory. With the other casks all degrees of fermentation were encountered, from juices with gravities of 1.041 and 1.038 down to 1.003 and 1.000.

It is obvious from the above results that with a juice obtained by the cold process, largely from culinary fruit, it is unsafe to attempt to store in plain wooden vessels. Some improvement is shown by the casks treated with some form of lining, but the juices stored in the lacquered casks had lost gravities varying from 3° to 27°. The Seitz filter was tested on three occasions during the filtration process and its efficiency was established, and thus there can be no reasonable doubt that the infection came from the casks themselves.

TABLE V.

STORAGE OF STERILE APPLE JUICE IN WOODEN AND METAL VESSELS.
(Original Gravity of Juice, 1.045).

No.	*Type of Storage Vessel.*	*Treatment of Vessel.*	*Specific Gravity of Juice. after 12 months.*	*Condition of Juice after 12 months storage.*
A	Cider cask	Steamed 1 hour : treated with 1 gallon calcium bisulphite for 1 hour.	1.037	Cloudy : considerable evaporation : surface covered with vinegar plant and mould.
B	do.	Treated with 40 c.c. liquid SO_2 for 24 hours.	1.038	Cloudy : some mould on surface.
C	do.	do. do. do.	1.031	Brilliantly clear liquor : mould on surface.
D	Beer cask.	Dukeron lining : treated with 1 gallon bisulphite for 1 hour.	1.018	Slight haze : mould on surface.
E	Cider cask.	Bottomley Cask enamel lining : treated with 1 gallon bisulphite for 1 hour.	1.041	Clear juice : very thick film of mould : juice of good flavour.
F	do.	Nobel Cask enamel lining : treated with 1 gallon bisulphite for 1 hour.	1.028	Brilliant juice : very slight vinegar and mould film.
G.1	do.	Dukeron lining : treated with 30 c.c. liquid SO_2 for 60 hours.	1.042	Cloudy juice : some mould.
G.3	do.	do. do. do.	1.018	Very cloudy : thick film of mould.
H	Beer cask.	Treated with 40 c.c. liquid SO_2 for 4 hours.	1.000	Cloudy juice : slight vinegar film.
J	do.	Treated with 40 c.c. liquid SO_2 for 12 hours.	1.003	Clear juice : slight vinegar film.
K	Metal cask (lacquered) 10 gallons.	Treated with 1 quart 2% SO_2 for 6 hours.	1.033	Brilliant but very dark coloured juice : metallic taste.
L	do. do.	do. do. do.	1.045	Brilliant juice : lighter colour than K : very slight metal taste.
M	Stainless Steel (5 gallons).	Treated with 1 pint 2% SO_2 for 6 hours.	1.042	Clear : clean attractive flavour : no metal taste.

GENERAL DISCUSSION.

(a) Sweetness and Acidity.

The task of assessing the possible popularity of an apple beverage is extremely difficult. It must be remembered that the juice will be consumed largely for quenching thirst, and will be taken fairly quickly, and not merely sipped. This fact has an important bearing on the relative proportions of sugar and acid which should be present. An excess of either constituent will not be so noticeable when the juice is being tasted as one of a whole series of juices as when a whole glass-full is consumed at once. Consequently, in these experiments, an attempt has been made to extend the tastings over a long period, and to drink various juices under similar conditions at intervals of a few days. In this way it is possible to obtain an idea of the character of the juices under actual drinking conditions. If a series of juices are tasted one after another in quick succession, a less accurate idea of their quality as beverages is obtained.

By this method, the opinion has been formed that a juice is most palatable when it possesses sugar and acid contents lying within certain ranges, viz.:

Specific gravity	1.045—1.055
Acidity (as malic acid) ..	0.50 —0.75%

The tests have indicated that it is not possible to decrease the sharpness of a strongly acid juice merely by adding sugar and thus raising the gravity. When a juice with a gravity of 1.070 and an acidity of 1.0% is tasted, the high sugar content is noticeable as a sickly sweetness, whilst the penetrating acidity becomes evident after the sweet taste on the palate has disappeared. The above ranges for gravity and acidity would thus appear to be important, and the sharpness of juices with high acidities should be reduced by blending or by chemical means rather than by the addition of sugar.

There are indications that the " body " of an apple juice is increased by the addition of sugar, but it is most important that the thirst quenching qualities of the drink should not be sacrificed to increase " body." It is probable that, with the cold processed juices, it is advantageous to have a high gravity in the juice, but even in this particular case the gravity should not greatly exceed that suggested above.

(b) Cold and Hot Processing Effects.

It has been stated previously that the outstanding differences between the cold and hot processed juices are that the cold drinks, which have been passed through the sterilising filter, are characterised by fresher and cleaner flavours than the pasteurised products, but the flavours are less intense than those of the pasteurised juices. The hot processed juices also have heavier flavours, and less noticeable acid characters. In connection with the characters of the pasteurised juices it should be stated that the juices were pasteurised in bottle, and not by the flash pasteurisation method discussed later in the report.

It was stated at the Fruit Juice Conference in Berlin in 1937 that the production of apple juice in Germany was equally divided between the hot and cold processes. Large manufacturers utilised the cold process, whilst the smaller makers, who could not afford the expensive tank storage system, made use of the hot process, either bottling the juice at once, or storing it in glass jars of about 6—10 gallons capacity. It was also mentioned that the cold and hot processed juices differed greatly in character, but that it was thought possible that suitable outlets could be found for both products.

The experiments described above suggest that the cold process is particularly suitable for cider fruit, where a full and permanent flavour exists in the freshly expressed juices, and a suitably intense flavour remains after sterile filtration. However, the actual position in this country at the moment, and probably for many years to come, is that the fruit which will be available for apple juice production will be of the dessert and culinary types, which are low in tannin and are consequently less intensely flavoured in the form of juice.

At the present stage, it is not possible to state which process should be adopted. The experimental results given herein are presented with a view to indicating the differences which have been observed between the two processes. Opinion seems to be equally divided between the two types of products at the present time, and it may well be that eventually there will be a need for both hot and cold processed products in which the well-defined differences will appeal to different sections of the community.

(c) Aerated or Still Drinks.

Manufacturers of apple juices in this country appear to be influenced in their choice of product by the German industry in which the juice is always sold without aeration. Conditions, however, may be different in the two countries. There is good reason to believe that very large quantities of apple juice are consumed by the members of the health organisations in Germany during their physical training. In this case, an aerated drink would be inacceptable, whereas for domestic use such a beverage might be definitely preferred. Consequently, it is possible that aeration may be desired in this country by the consumer to whom apple juice will appeal. The degree of aeration should, however, be very carefully controlled in order that there should be no similarity in condition with the present type of mineral waters.

One definite point in favour of carbonation is the added stability which it confers on the juice. The experimental results contain several examples where carbonated juices were preserved for a long period, whereas the still beverages quickly fermented.

Finally, reference should be made to the attempt to assess the flavours of three juices on Tasting Day 1937. A very definite preference was shown then for the Seitz-filtered, aerated juice in direct comparison with the Seitz-filtered still and the pasteurised juices.

(d) Stability of Products.

The unsuitable nature of the cold processed juices was the only unsatisfactory feature of these products in the present series of experiments and some attention must be paid to the possible reasons for the results.

In the first place, it must be emphasised that the information given in Tables I, II, and III, referring to the stability of the bottled juices, must be considered in relation to the description of the actual method of bottling described in the text. It will be seen that apart from the Seitz E.K. filter and the sulphuring wheel, no special apparatus was used. The bottling was done by hand, and it is certain that better results would have been obtained if special bottling plant had been available. Even allowing for defects in procedure, it is considered that the experimental results indicate that apple juice made from English culinary and dessert fruit presents certain serious difficulties in stabilisation by the cold process, and that in comparison with Continental juices, the English type appears to be very easily fermentable.

Three sources of infection are possible: inefficiency of the sterilising filter, insterility of bottles and corks, and infection from the atmosphere. The data already presented show quite definitely that the Seitz filter performed the sterilisation of the juice in a thoroughly efficient manner, but the cleaning of the bottles from a bacteriological point of view was shown by occasional tests to be unsatisfactory. The great variation from bottle to bottle points to inefficient sterilisation, which is notable in view of the fact that the treatments used were considerably more drastic than those commonly adopted for cider and other products. The temperatures were constantly checked, and the SO_2 used on the wheel was standardised at 2% and fresh material substituted whenever the strength fell appreciably below this figure. Some evidence has recently been found for believing that corks are possibly the cause of some mould growth in the bottled products. It has been necessary to soak the corks for 4 hours in 2% SO_2 solution to obtain absolute sterility.

It is difficult at present to make any statement regarding possible infection from the atmosphere. No attempts were made to work in a completely sterilised room, although the floor and ceilings of the room used were cleansed by spraying with 2% SO_2 solution before bottling commenced. The copious use of 2% SO_2 for cleaning various pieces of apparatus contributed such a pungent aroma of the disinfectant to the atmosphere that working conditions became quite unpleasant. The bottles were also kept neck downwards after being taken off the wheel, and were filled under the special protecting cap and corked immediately after filling. Plate cultures were exposed to the air on the occasion of the 1936 bottling, but the only micro-organisms which were found consisted of penicillium mould and acetic bacteria. Moulds, however, were not found in the juices bottled in 1936.

A very careful study of bottling methods was made in March 1938, when a bulk of apple juice from a German source was to be bottled by the cold process. Every possible precaution was taken, and a strong smell of SO_2 pervaded the room in which the bottling took place. Bacteriological tests of a quantitative nature showed that the Seitz filter delivered a sterile juice and that the bottles coming off the sulphuring wheel were completely sterile, but juices developed mould growth after 6 day's incubation. Three Petri dishes of the usual type were exposed to the air for 10 minutes, under different conditions in the room in which the bottling was done. The results are shown below.

Methods of Exposure of Plate.	*Total Count.*
1. Placed 18in. from floor near wall	6 moulds.
2. Placed 3ft. 6in. from floor in centre of room ..	15 moulds.
3. Kept in continual movement around and across the room at varying heights	16 moulds.

These results indicate the possibility of infection from the room being the cause of instability of the juices, although from a quantitative point of view, the above figures do not explain how infection can take place with such regularity when the comparatively small necks of the bottles are exposed to the air for periods of 3 –5 seconds only.

German scientific workers emphasise the fundamental importance of sterile conditions in the bottling room, and in all future work the experiments will be carried out in a special room which is now being prepared.

D. EXPERIMENTS ON THE MACERATION, DE-AERATION AND FLASH PASTEURISATION OF APPLE JUICES FOR IMMEDIATE CANNING OR BOTTLING.

The experiments described in the preceding sections of this report have dealt with the production of apple juice by the completely cold process with immediate bottling, and with the pasteurisation of the juices in the actual containers in which the juice would be eventually sold to the consumer. During the spring of 1937, however, the production of apple juice was being considered by a number of firms and the various available processes had been very thoroughly discussed with a large number of interested fruit-growers and food and beverage manufacturers. It became apparent that, from a marketing point of view, the can possessed many advantages over the bottle, and the Metal Box Company approached the Research Station authorities regarding the possibility of producing an apple beverage that could be canned immediately without any danger either of fermentation, change in appearance, or of contamination from the can. Arrangements were made in April 1937 for collaboration between the Metal Box Co. and the Research Station with respect to this particular problem, and the investigations which are described later were carried out at Long Ashton with the aid of various members of the Research Staff of the Company. This opportunity was taken to study the effects of de-aeration and flash pasteurisation on the stability and flavour of the juice, and to discover whether any method was available for producing a fuller-bodied beverage than the products from culinary juices mentioned earlier in this report. To investigate these latter points the Metal Box Co., afforded assistance by providing some of the necessary plant and by extending the period of collaboration until March 1938.

Before describing the results of the experiments at Long Ashton two points of technical interest will be briefly discussed, and references made to American literature relating to the problems involved.

De-aeration.

It has been recognised for a long time that fruits and fresh juices contain oxidase systems which exert specific and far-reaching effects. The browning of apple tissue when in contact with air is the result of changes brought about by a specific oxidase. Oxygen is essential for the oxidase activity to continue, and consequently the removal of air, which naturally involves the removal of oxygen also, is an important factor in the suppression of oxidase action. It has been stated by Marsh (1) that "loss of flavour, loss of colour in red juices, clouding in the case of brilliantly cleared juices and pin-holing of the cans, are attributable to oxygen contained in the juice." Elmer and Cruess(2) mentioned that de-aeration is now a recognised procedure in the production of canned orange and lemon juices, enormous quantities of which are marketed in North America.

Apart from the effect of de-aeration on the ultimate flavour of apple juice, it was thought possible that the removal of oxygen might reduce the corrosive action of the juice on the can to such an extent that the need for elaborate precautionary measures such as lacquer and wax linings would be obviated. This has not proved to be the case, but the possibility provided an additional reason for studying the de-aeration process.

It should be added that de-aeration is not practised in Germany, nor is it considered there to be of any importance.

Flash Pasteurisation.

The whole of the pasteurisation programme at Long Ashton previous to the spring of 1937 had been carried out by the method outlined in Section A of this report. However, in very recent years pasteurisers of a new type have been perfected in Germany and U.S.A. In these, the juice is exposed to a very high temperature (180°—195°F.) for a comparatively short time (10—30 seconds). The shorter period of heating renders the juice less liable to flavour changes, despite the high temperature used. It is necessary to arrange for strict control over the pasteurisation temperature and the rate of flow through the pasteuriser, together with the cooling of the juice as quickly as possible after the heat treatment.

EXPERIMENTAL.

Preliminary Experiments.

The main object of the experiments was to produce an attractive, palatable beverage entirely from culinary apples. The experiments were commenced in March 1937, when the only fruit available in any quantity was gas-stored Bramley's Seedling apples. It was decided to use this fruit, the acidity of which was 0.64%, instead of 1.2% in the fresh, unstored condition. The juice made in the normal way was thin and lacking in fruit character, and attempts were made to improve the flavour by means of maceration. The apples were milled and the pulp allowed to remain for 12 hours before expressing the juice. The juice in its final form was certainly more fully flavoured than the initial juice, but a harsh, rough aftertaste was so noticeable that the general character of the juice had become less attractive than the control. In view of this result, experiments were carried out to discover whether the full flavour could be introduced without the harsh aftertaste by expressing the juice immediately and returning varying quantities of the press-cake in a disintegrated condition. It was found, after many tests, that maceration for 24 hours of 35—40 lbs. of press cake per 100 gallons of juice gave a final product which was generally superior to that made by omitting the maceration process. The results were so definite, and the quality of the juice made by including the maceration treatment was so good, that the process as outlined above was used in all the subsequent experimental work.

Following on the experiments concerning maceration, further series were carried out to determine the best methods of canning and bottling the juices. The pasteurisation in can was done at 140°F. for 30 minutes, allowing 8 minutes for the temperature to reach 140°F. throughout the cans. A cloudy, unfiltered juice was used in these experiments, and, in general, the heat treatment was sufficient to give a completely sterile juice. The use of higher temperatures was impossible, on account of the low melting point of the wax used for lining the cans. In several cases there was a foreign taste, which was attributed to the contact of juice with the wax, but most of the experiments indicated that the treatment did not result in any considerable deterioration of the juice. The "cooked" taste was very noticeable, however, when a cold processed juice was available for comparison.

A further experiment was carried out in which a bulk of Bramley's Seedling apples from several sources and in various conditions was milled and the juice, after maceration and enzyme treatment, was adjusted to a specific gravity of 1.050 and a malic acid content of 0.67%.

The following treatments were carried out.

3N. Centrifuged juice filled into unsterile bottles and waxed cans and pasteurised at 140°F. for half-hour.

3P. Centrifuged juice filled into unsterile bottles and plain cans and pasteurised at 140°F. for half-hour.

3R. Centrifuged juice filled into unsterile bottles and waxed cans + 70 p.p.m. SO_2 and pasteurised as before.

2T. Seitz E.K. filtered juice filled into sterile bottles and waxed cans and pasteurised as before.

The cans and bottles were examined after a few days. All the centrifuged juices had thrown a heavy deposit, but there was no fermentation and the flavours of 3N and 3R were good. The juice packed in plain cans, however, was completely spoilt by a strong metallic taste. The cans were badly etched, especially around the neck. The Seitz filtered juices were sound, and apart from a few cans, remained free from fermentation for 12 months.

It was decided to remove the deposit from the cloudy juices by centrifugation, and to pack again according to the above scheme. The centrifuged juice was more attractive in appearance and possessed only a slight haze. The re-pasteurised juices were completely stabilised by this means, and a very fruity and attractive apple juice was prepared. The few samples remaining in March 1938 were still sound, and had thrown only a mere trace of deposit. There was, however, a slight but gradual loss of fruit flavour throughout the storage, and it was decided to proceed with a series of experiments to minimise the effect of pasteurisation and to prevent losses of flavour on long keeping.

Large Scale Experiments (December 1937 March 1938).

For the purposes of these experiments two new pieces of apparatus were used. In the first place a special plant was devised for the deaeration of the juice. A fine stream of juice was sucked into a

5 litre round-bottomed glass flask which was maintained under a vacuum of 29 inches. The juice was sprayed over the surface of the flask, thus exposing a large area and allowing the maximum removal of gases. An elaborate system of valves and flasks enabled the process to be continued without a break, and the de-aerated juice, from which the dissolved gases had been removed under vacuum, was collected under atmospheric pressure. Figure II illustrates the plant.

Secondly, a small flash pasteuriser was procured from Germany. This is illustrated in Figure III. The outline of the inner shell of the pasteuriser can be seen in the photograph.

The juice from the de-aerator was pumped to a reservoir about 5 ft. high and allowed to run through the pasteuriser by gravity, thus maintaining a constant flow. The juice remained in the plant for about 30 seconds, and in general, the output was equal to 10 half-pint cans per minute. The juice left the pasteuriser at 185°—190°F. and was cooled to 140°F. by passing through a coil immersed in running water. At this temperature it was received into cans which were not previously treated in any way. Bottles, when used, had been given the usual detergent soaking followed by rinsing. The containers were immediately crown-corked, washed, inverted for 2 minutes, dried and stacked. They were allowed to cool from 140°F. without any artificial aid.

The pasteuriser appeared to be made of some form of aluminium, but this metal cannot be recommended for such a purpose. Much corrosion occurred, and although no trace of metallic taste was noticed, the loss of metal from the walls of the machine was very serious.

The various factors which were considered to be of importance were examined in two comprehensive experiments, and finally a large bulk of juice was made according to the most satisfactory scheme discovered in the previous tests. These series of trials are described separately.

(a) Mixed Dessert and Culinary Juices.

A mixed lot of various varieties of apples were procured from the Research Station grading room, including Laxton's Superb, Blenheim's Orange, Cox's Orange Pippin, Bramley's Seedling, Lane's Prince Albert, etc.

The experiments were carried out according to the scheme in Figure IV.

It will be seen that the experimental procedure was designed to obtain information on the following specific processing details.

(*a*) Preliminary treatment of juice : *i.e.* de-aeration, pasteurisation and control (no treatment).

(*b*) Maceration.

(*c*) De-aeration in association with flash pasteurisation.

(*d*) Filtration through muslin instead of pulp (*i.e.* a cloudy instead of a clear juice).

(*e*) Pasteurisation in can instead of flash pasteurisation.

The juices were adjusted to the desired specific gravity by adding a boiled sugar syrup. This was done after the preliminary treatment, and immediately prior to the filtration. The pectin-decomposing enzyme was used at a strength of 0.1%.

The flavours of the experimental juices 3 months after canning are given below :—

FLAVOUR OF APPLE JUICES NOS. 9—20.

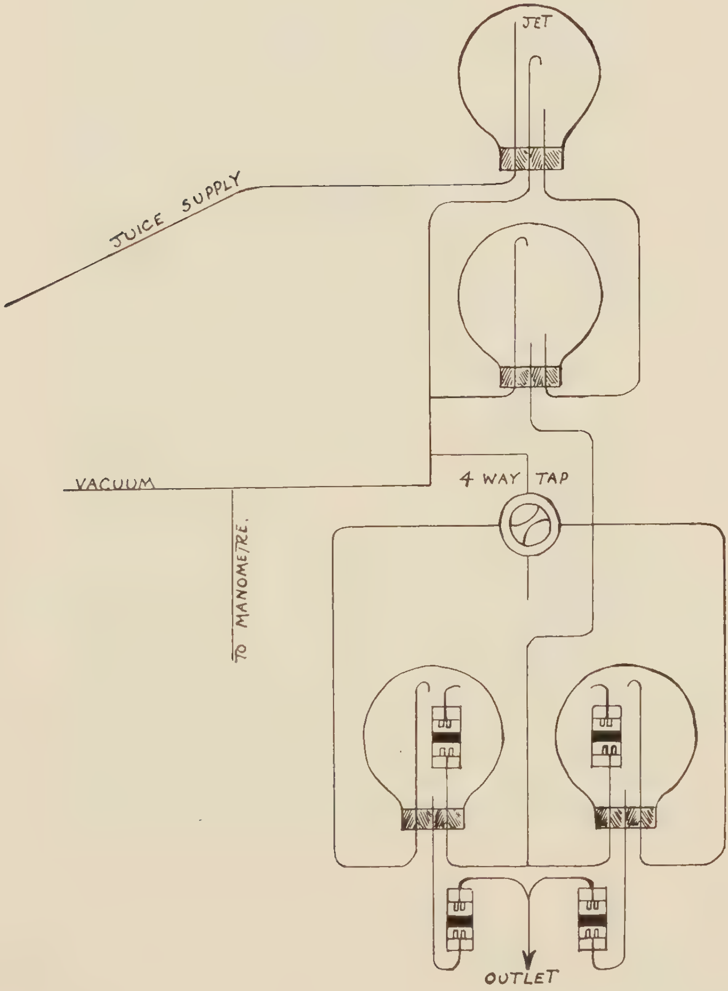
No.	*Flavour.*
9.	Full, but rough aftertaste.
10.	Poor ; lacking in fruit character.
11.	Definite pasteurised taste. Unattractive.
12.	Poor ; lacking in fruit character.
13.	,, ,, ,, ,,
14.	,, ,, ,, ,,
15.	Good. Full, clean, attractive fruit character.
16.	Almost as good as No. 15.
17.	Less intensely flavoured than No. 16, but preferable to Nos. 10—14.
18.	,, ,, ,, ,, ,, ,,
19.	Very poor. Lacking in all fruit character.
20.	,, ,, ,, ,, ,,

The first juice, No. 9, was centrifuged and not filtered, and although in the preliminary experiments this type of juice was fully flavoured and attractive, the present juice was spoilt by a rough character that was quite noticeable on the palate.

Nos. 10—14 were uniformly poor, and very little difference was detectable between any of them. These juices received a preliminary de-aeration, and Nos. 10 and 11 were macerated, and Nos. 13 and 14 were not so treated. No noticeable effect of maceration was found in these juices. The sample which was pasteurised in can possessed a noticeable cooked taste and a further character which was difficult to define. This may possibly be attributed to the heating of the juice in contact with the wax lining, for the juice contained many " scales " of wax which had been removed from the can during the processing.

FIGURE II

DEAERATOR



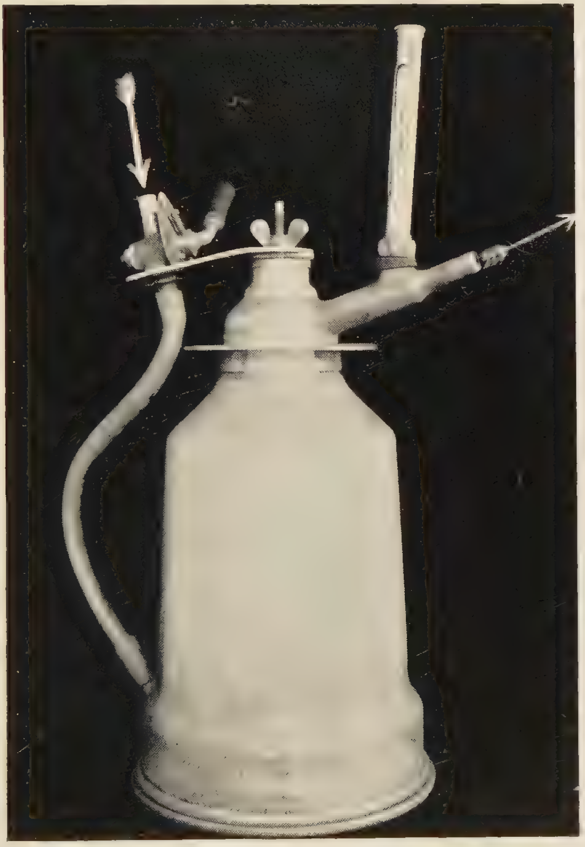


FIGURE III. Flash Pasteuriser.

FIGURE IV

SCHEME FOR PROCESSING MIXED CULINARY & DESSERT APPLE JUICES. NOS· 9 - 20

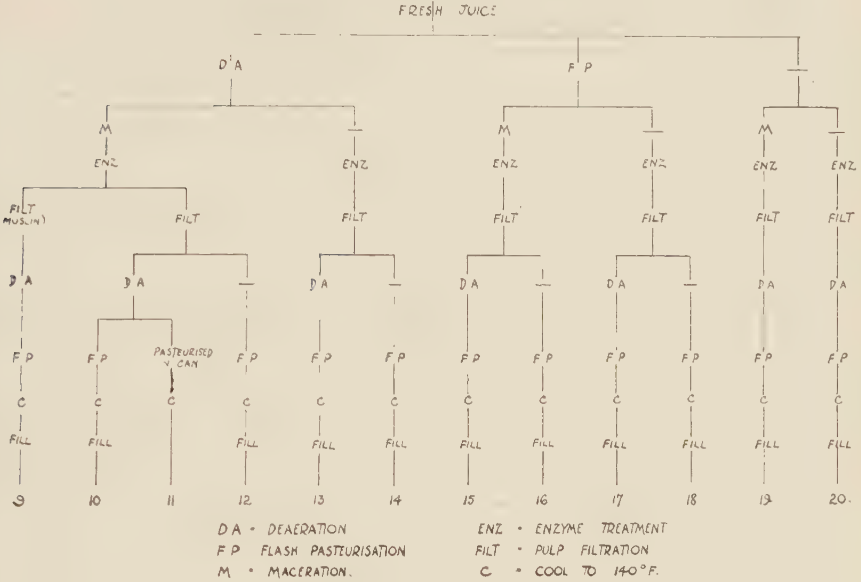
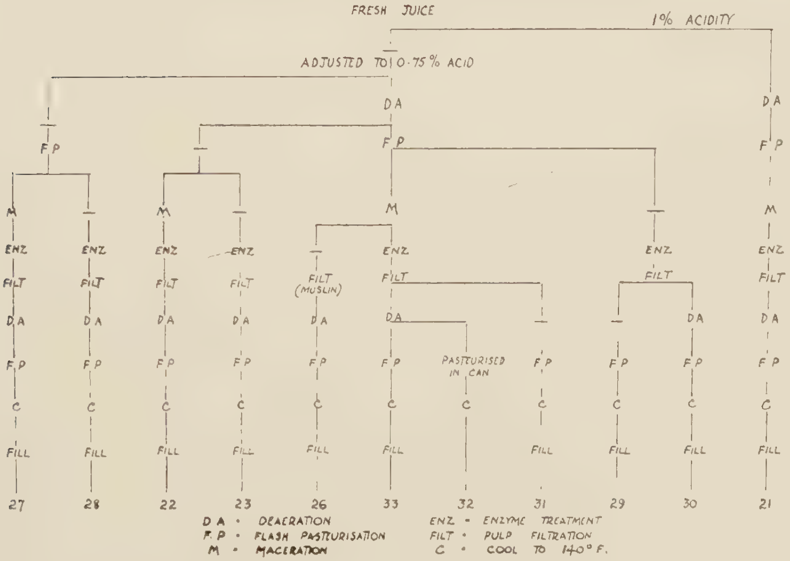


FIGURE V

SCHEME FOR PROCESSING BRAMLEY'S SEEDLING JUICE. NUMBERS 21 - 33.



The effect of the initial flash pasteurisation was convincingly shown by the flavours of Nos. 15—18. A consideration of the precise observations on flavour for these juices indicates a preference for initial flash pasteurisation, maceration, and for de-aeration. No. 15, the best juice in the series, had been subjected to all these treatments, whereas in No. 16 the final de-aeration was omitted. Nos. 17 and 18 were not macerated, and the latter was not de-aerated before the final pasteurisation into cans.

The poor flavour of Nos. 19 and 20 indicated the need for some form of initial treatment for the juice previous to the maceration and enzyme action.

With regard to stability, all the juices were completely stabilised by the final flash pasteurisation treatment into cans. Exhaustive incubation tests at 25°C. for 2 months failed to show any signs of fermentation or mould growth.

The appearance and clarity of the juices, however, was not quite so satisfactory. Samples incubated for 2 months at 25°C. were capable of being poured out in a clear condition without being absolutely brilliant. The last 50 cc, however, was cloudy and contained a slight deposit of amorphous light-coloured material, and when this was mixed with the clear juice, the whole of the drink became quite hazy.

It will thus be seen that as a result of the experiments, Nos. 9—20, preference was shown for a preliminary flash pasteurisation of the juice, followed by maceration and enzyme treatment, and for a final de-aeration and flash pasteurisation immediately prior to bottling or canning. The enzyme action was incomplete, however, and longer time should be allowed for this important process.

The use of plain cans was quite unsatisfactory. The cans were etched, though not badly, but sufficient solution of metal had occurred to impart a strong foreign taste to the juice. The wax-lined, lacquered cans appeared to be completely unaffected by the processing, except where the pasteurisation was carried out in the can. Flaking-off of wax occurred in this case.

(b) Bramley's Seedling Juice.

In view of the improvement of flavour obtained in the preceding experiments by de-aerating juices previous to their final flash pasteurisation, it was decided to repeat the experiments 9—20, and to include an extension to cover the combined treatment of the freshly expressed juice.

Half a ton of gas-stored Bramley's Seedling apples were used for these experiments in February 1938. The fruit was in perfect condition and the acidity was still very high (1.0%). The gravity of the juice (1.048), was relatively high for this variety, but the acidity was so penetrating that it was decided to reduce the natural acidity by means of pure precipitated chalk. The main bulk of the juice was adjusted by this means to 0.75% malic acid, but a small quantity was left with the full acidity. It will be seen from Figure V, which illustrates the various processes, that different bulks of freshly expressed juices were either de-aerated, flash pasteurised, or subjected to both treatments.

The exact assessment of flavour differences with this series was more difficult than in the previous experiments, and many of the juices were indistinguishable from each other. However, the concensus of opinion amongst those who tasted the juices enabled the following table, giving the decreasing order of attractiveness of the juices, to be prepared :—

33 31
30 29 (33 and 31 slightly superior to 30 and 29).
27 28
22 23
26 32
21

This differentiation in the flavours of the juices was obtained by tasting the juices under new numbers so that the actual treatment applied to any particular juice was unknown to the tasting panel. The most important point issuing from the experiments is that the best juices, 33, 31, 30 and 29, had all received the preliminary de-aeration treatment followed by flash pasteurisation of the freshly expressed juice. Some further evidence in favour of maceration was obtained by the superiority of Nos. 31 and 33 in comparison with Nos. 29 and 30, which were not macerated.

Although the differences were very slight, there was a tendency for No. 33 to be preferred to No. 31, and for No. 30 to be preferred to No. 29. This indicates the good effect of the de-aeration prior to the final flash pasteurisation into cans or bottles.

As a result of these two series of experiments the following was chosen as the standard procedure to be adopted for this type of apple juice processing : —Mill fruit and express juice ; de-aeration ; flash pasteurisation ; maceration ; removal of solid tissue ; enzyme treatment ; filtration ; de-aeration ; flash pasteurisation ; cooling ; canning or bottling.

(c) Semi-commercial Bulk Test.

In view of the increasing difficulty of obtaining fruit of suitable nature, it was decided to conclude the season's experimental work by making a large quantity of juice according to two main processes. The standard procedure given above was used for the main bulk (2,000 cans), whilst other quantities of juice were made by Seitz E.K. filtration into sterile cans and bottles which were prepared and bottled (or canned) in precisely the same way as described in Section A of this report. A small quantity of juice was given a shortened treatment, namely, enzyme action, filtration, final de-aeration and flash pasteurisation into cans. This was taken as the minimum treatment and was used as a control. The scheme for the various treatments is given in Figure VI.

The fruit used, Bramley's Seedling, was mostly taken from a Kent gas store, but about 5% consisted of small ripe apples which had not been stored at low temperatures.

The actual making operations are of importance. 1½ tons of the fruit were milled on Thursday, March 3rd, 1938. The juice was strained through a coarse staybrite sieve and was immediately de-aerated and flash pasteurised at 185°F. for 25 seconds. This process occuped 17 hours. The pasteurised juice was cooled as quickly and as effectively as possible, and was collected in a 600 gallon slate tank in which the disintegrated press cake was mixed. Maceration proceeded for 24 hours, and in view of a sudden rise in outside temperature, it was decided to centrifuge the juice, after the removal of the bulk of the apple tissue by sieving. 0.1% enzyme was added and allowed to act for 48 hours at an average temperature of 12°C. Pulp filtration was effected with ease, and the brilliant juice was finally de-aerated and pasteurised at 190°F. for 30 seconds, and filled into cans and bottles at 140°F. The cans after filling were inverted for half a minute, washed, dried and stacked. The Seitz filtration was carried out as described previously. Before being filled the cans were filled with 2% SO_2 for 2 minutes and allowed to drain.

The juices were tasted one week after canning. It should be emphasised that the effect of de-aeration and other processes may not become apparent for some time, and for this reason the effect of the various treatments on the flavour during long term storage will be the subject of a communication in a later Annual Report. For the present, it must suffice to give the flavour of the juices at a comparatively early stage in their storage life. The flavours were as follows :—

No. 36. *Control Juice (Shortened Hot Process).*

This juice was attractive and possessed a full fruit character. The flavour was rather too brisk but there was no taste of a "cooked" nature. There was a pleasing freshness about the flavour which contributed to the general attractiveness of the drink.

No. 35, 37. *Complete Treatment (Hot Process).*

This juice differed from the preceding sample by reason of its heavier character, and more mellow flavour. There was a more intense total flavour and the juice was quite distinctly fruit flavoured. Whilst lacking the briskness of the former juice, the general character of the product was such that it would probably make a greater appeal to the general public than the preceding juice.

No. 39, 40. *Cold Process.*

The difference between this juice and the heat treated juices was very marked. Although the juice was characterised by a pleasing fresh apple character, the lack of body allowed the acidity to become too prominent, and in consequence there was a distinctly thin and "hungry" taste to the drink. The result seems to indicate that juices to be cold processed should be chosen for their medium acidity and relatively high sugar/acid ratio.

Type of Container.

In all the experiments described, *i.e.* Nos. 9–40, juices were filled into waxed and plain cans. The unanimous results of the experiments indicated that waxed cans were entirely suitable for the reception of apple juice, but that the plain can was quite useless. In some cases, the juice was actually discoloured by contamination with metal in the plain can, but in general only a slight etching of the can was noticeable. Even in these cases, however, the effect on flavour was most marked. De-aeration of the juice did not exert any appreciable effect on the corrosion of the tin by the apple juice, but corrosion was greater with the more acid juices. None of these ill effects were observed in the waxed can series.

With regard to bottles, a large bulk of "split" size bottles (7 fluid ozs. capacity) were filled in exactly the same way as the cans. They were given the normal washing treatment as described earlier in this report, but were not rinsed with SO_2. Although the juice in cans was stabilised by the flash pasteurisation, the bottled juice quickly showed signs of fermentation when incubated, and the complete stock was subsequently pasteurised in bottle at 140°F. for 30 minutes after the whole of the contents of the bottles had reached the necessary temperature. This treatment has so far proved to be satisfactory in suppressing fermentation.

In order to discover the cause of the fermentation in bottle an experiment was carried out to determine whether any differences existed in the cooling behaviour of canned and bottled juices. A wax-lined can, the outside of which was covered with printing, a plain "split" and a 10 oz. beer bottle were filled with juice at 140°F. and closed with corks, through which thermometers were fitted. The temperature of the juice was taken at various intervals. An indication of the rate of fall of temperature of the two containers can be seen from the figures in Table VI.

TABLE VI.

Loss of Temperature from Pasteurised Apple Juice Immediately after Canning and Bottling.

(Temperature of Juice entering Can or Bottle = 140°F.).

Minutes after Filling.	*Wax-lined Can.*	*7 oz. Bottle.*	*10 oz. Bottle.*
½	135°F.	127°F.	129°F.
1	134°	124°	128°
5	130°	120°	125°
10	125°	116°	120°
15	121°	111°	117°
25	115°	106°	108°
40	106°	97°	102°
45	—	—	98°
55	99°	91°	—
60	—	—	93°

The data in Table VI show that the juices filled into bottles lose considerably more heat then the canned juices. The initial temperature of 127°—129°F. is not sufficient for sterilising the surfaces of the bottles.

In view of the difficulties inherent in obtaining biologically clean bottles, it would probably be advisable to fill the juice into bottles at such a temperature that after the bottles themselves have been warmed by the hot juice, a temperature of about 140°F. is shown. The juice issuing from the flash pasteuriser should be at 150°—155°F. for this purpose.

Conclusions relating to Maceration, De-aeration, Flash Pateurising and Containers.

It will be obvious from the data presented at the present stage that final generalisations cannot be made on the question of processing apple juice. The following points regarding the various methods, however, have been elucidated :—

(i) Preliminary de-aeration protects the juice against excessive changes of flavour during pasteurisation.

(ii) It is advisable to carry out both processes in (i) on the expressed juice, either before or after maceration.

(iii) Enzyme action is essential for the quick and easy manipulation of juices, and to minimise the danger of deposits forming later in bottle or can.

(iv) Maceration as carried out in these experiments has generally a beneficial effect on flavour.

(v) Flash pasteurisation of the juice at 190°F. for 25—30 seconds, followed by filling into cans at 140°F., produces a product of perfect sterility.

(vi) Plain cans are quite useless for apple juice, but wax-lined lacquered cans are entirely suitable.

(vii) Flash pasteurisation is more satisfactory than heat treatment in cans.

Commercial Processing.

It is very difficult to translate the results obtained into a series of recommendations for large scale commercial production of apple juice. No attempt will be made to suggest a definite process or series of processes for commercial use, but several considerations arise which can be conveniently mentioned here.

Fruit Supplies.

In the first place, the type of raw material is of fundamental importance in considering the most suitable process. Standardisation of the finished apple juices is most important and if a straightforward canning or bottling process such as has been described above is adopted, it will be impossible to do more than a rough form of blending to arrive at some sort of a standard product. A fruit grower or small manufacturer will be limited by the type and varieties of fruit available, and although there is considerable scope for blending the right sorts of apples which mature during the same period, it is not possible to hold early season, low acid fruit until the late season, sharp varieties, such as Bramley's Seedling, are available. Consequently, if regular daily canning or bottling is considered, it will be necessary to arrange for very careful selection of varieties to make a blend which must be standardised with regard to sugar and acidity, or else the natural sugar and acidity must be brought as near as possible to the desired standard values by adjustment with sugar and fruit acid solutions. Juices with very high acidity will probably need treatment with chalk or potassuim carbonate. The various series of experiments that have been carried out since 1932 at Long Ashton have suggested that the juices made from various varieties of apples which possess distinctive varietal characters before pressing do not retain such characters in the juice. Consequently, if the sugar and acid contents can be approximately adjusted to some suitable standard, it may be that the juices from a wide variety of apples would be sufficiently similar to enable daily processing into cans to be carried out and yet ensure adequate standardisation of the product.

Secondly, it is quite possible to store early season's juice in bulk, either by the use of Boehi tanks using 120 lbs. CO_2 sq. inch, or merely by pasteurising the juice and receiving it in a glass-lined steel or stainless steel tank. With suitable precautions it is also possible to store the hot processed juices in perfect safety in considerable bulks. This method has the advantage of allowing the changes in pectin material to take place prior to the final processing and the canning or bottling of the juice. In Germany smaller firms make extensive use of 6—10 gallon glass jars for bulk storage.

Thirdly, there is the possibility of using only one variety of apple, and thus overcoming the difficulties of standardising the juices. Bramley's Seedling is the only variety which could give a sufficient bulk of juice for any considerable commercial venture, and the results of the experiments in which this variety alone was used show that a palatable juice can be made. It seems, however, that blending with other varieties will tend to improve the flavour of the Bramley juice, and an attempt should be made to blend in other fruits. The question of blends is so much a matter of the local conditions that it is not possible to suggest definite varieties for use in this way. But as a general rule, sweet varieties should be mixed with sharp sorts, and varieties coming to maturity simultaneously should be blended together.

Fourthly, although the results of the cold processed apple juice experiments have not been satisfactory, this may be attributed to the lack of opportunity of providing suitable precautions for sterile filling. The cold process should be regarded as an attractive possibility, but it is essential that the difficulties associated with the process should be fully appreciated.

Finally, an indication can be given as to what type of fruit is suitable for manufacturing into apple juice. Absolutely clean, unbroken fruit is, of course, ideal, but it has been found possible to depart considerably from this standard without affecting the ultimate flavour of the juice to any appreciable extent. The apple juice manufacturer is limited in the price he can pay for his fruit, probably from £3 10s. to £5 per ton, and this price will determine the quality of fruit that will be offered by the fruit grower to the factory. Very large, very small and misshapen fruit are quite satisfactory, and insect damage is of no consequence. Fruit that has become badly damaged by bruising, rots or mildew and moulds is unsuitable, and should be removed. A very effective way of discarding such fruit is to use a washing machine, for the fruits with damaged skins will absorb water and sink to the bottom, whilst the sound apples will float on the surface of the water. Washing, too, performs a useful service in removing soil and dirt from windfall apples, and grass and other extraneous material from orchard grown fruits.

Order of Preliminary Treatments.

It has been pointed out to the writer that the good effect of the preliminary de-aeration and flash pasteurisation is likely to be nullified by adding the press-cake back to the juice after the initial treatment. This possibility was not foreseen when the schemes were originally drawn up, but as it was intended to develop a general process which would cover all types of conditions it was considered essential to stabilise the juice from the point of view of fermentation throughout the duration of the maceration and enzyme treatments. Since the removal of pectin is of such importance, the period of treatment will need to be extended to 2—4 days, and this increases the possibility of fermentation. Consequently, an initial flash pasteurisation is considered advisable and the de-aeration is then included as a necessary complement to the heat treatment. The actual removal of dissolved oxygen from freshly expressed juice by the method described was shown to be about 91%. In view of this very significant reduction in dissolved oxygen, together with the inactivation of the oxidases by the pasteurisation, it is quite possible that the addition of pomace to the juice will not seriously prejudice the intended effect of the preliminary treatment. The decision as to the most effective order of the preliminary treatments of de-aeration, flash pasteurisation, maceration and enzyme action is, however, complicated by a further factor. Quick manipulation is essential during the initial stages, and unless a means is found of cooling the pasteurised juice to a reasonably low temperature, the pomace will have to be added to a warm juice for the sake of speed. This will enhance the chances of fermentation during the maceration and enzyme periods. Consequently, it may be preferable to macerate the juice immediately after its expression from the milled fruit, and to de-aerate and flash pasteurise the juice after the removal of the macerate, and previous to the addition of the enzyme.

Adjustments for sugar and acid should be made after enzyme action and prior to filtration.

SUMMARY.

1. Unfermented apple juices were prepared by pasteurisation and cold sterilising filtration methods. Perfect stability was obtained with juices of medium acidity by pasteurising at 160°F. for 30 minutes. The cold process gave very erratic results, and this was shown to be due to factors other than the sterilising filter. The difficulties of obtaining completely sterile conditions during bottling are indicated.

   The differences in flavour between the two types of juice were as follows :—The hot treatment gave drinks with full flavours, in which varying degrees of " cooked " taste were noticeable, whilst the cold process produced beverages with remarkably fresh and clean aromas and flavour, but rather lacking in " body."

   Pasteurisation at relatively low temperatures was shown to be more effective in sterilising the more acid juices, but the bad effect of pasteurisation on flavour increased with the acidity of the juice.

   The bulk storage of apple juice in treated wooden or metallic vessels was examined. The results were variable, but in general wood was not satisfactory for long term storage. Stainless steel lacquered steel casks provided satisfactory storage conditions.

2. The production of an unfermented drink from apples, which could be stored in the bottle or can in which it would be finally marketed, was investigated.

The scheme for processing which gave the best results is as follows :—Milling and pressing the fruit ; de-aeration of juice under 29in. vacuum ; flash pasteurisation at 185°—190°F. for 30 seconds ; maceration of cooled juice with 40 lbs. press-cake per 100 gallons juice ; removal of macerate ; treatment with 0.1% pectin-decomposing enzyme for 48 hours ; adjustment to pre-determined specific gravity and acidity ; filtration of juice to brilliant condition ; de-aeration and pasteurisation as before ; cool to 140°F. ; can juice at 140°F. to sterilise containers ; allow to cool naturally.

Perfect stability with regard to fermentation has been achieved by this method, but a slight haze formed after 2 months incubation at 25°C.

Plain cans were shown to be useless, but wax-lined, lacquered cans were quite suitable.

Results in the bottles were more variable than with cans, and when they are used juices should be filled into them at approximately 150°—155°F. This temperature will probably vary with the type of bottle.

Attractive beverages were produced from Bramley's Seedling juice alone by the above method.

Acknowledgment.

The writer wishes to express his appreciation to the Metal Box Co., for making possible the experiments described in the last section of this report, and especially to the three research workers from the Research and Development Section of that Company, who were concerned with the actual experimental procedure. Special acknowledgment is made of the valuable help given by Mr. R. C. Curtis, B.Sc., in certain of the experiments, and by Mr. G. C. Myddleton (Metal Box Co.), in designing the de-aerator and for assistance throughout the canning investigations.

REFERENCES.

(1) Marsh, G. L. *Fruit Products Journal.* May, 1937.

(2) Elmer and Cruess. *Fruit Products Journal.* August, 1937.

RECENT DEVELOPMENTS IN FRUIT PRODUCTS RESEARCH AT LONG ASHTON.

By VERNON L. S. CHARLEY.

The investigation of fruit products at Long Ashton can be dated back to the inception of the National Fruit and Cider Institute there in 1903, for cider itself must be ranked as one of the most important products associated with fruit. As the work of the Institute developed, attention was paid to problems concerning other outlets for apples and fruits generally, and thus began the association of the Long Ashton Station with a wide variety of fruit products questions, the scope of which is indicated by the following list of papers published on the results :—

Cider apple jelly (Barker & Grove, 1914) ; Fermentation of plum juice (Grove, 1914) ; Pectins of cider apples and their uses (Barker, 1915) ; Glucose for jam making (Grove, 1916) ; Apple pomace for stock feeds (Barker & Wale, 1916) ; Apple vinegar (Grove, 1917) ; Cider apple jelly (Barker, 1917) ; Cold process preserves (Barker & Grove, 1923) ; Sulphur dioxide as a preservative for fruit (Barker & Grove, 1924).

In 1923 a new development occurred when the Canning Research Station at Chipping Campden became associated with the Long Ashton Station as a constituent part of the Department of Agriculture and Horticulture of the University of Bristol. Apart from an intensive study of canning methods by the Campden Station, consideration was given for the first time to the possibilities of utilising surplus soft fruits by their conversion into syrups. (Appleyard & Hirst, 1927). Fundamental work of an important nature was also carried out on the relationship between the sugar and acid contents and the " set " of jams on their keeping qualities (Hirst, 1927), whilst the preservation of tomatoes and different varieties of fruits and vegetables was discussed in the same year.

Although the researches in the subjects mentioned above were carried out as separate and isolated investigations to provide answers to specific problems, and not as various items in a planned and comprehensive research programme, several of the published reports have been of the utmost importance to the fruit industry. Undoubtedly the outstanding example of this is the work on sulphur dioxide as a means of preserving fruits. The refinements introduced into the original method which were evolved in 1924 were widely adopted, and the Long Ashton method remains the standard one for fruit preservation by chemical means. Again, the manufacture of cider apple jelly was extensively carried out on a commercial scale at Long Ashton, and at other centres under Long Ashton direction, during the latter years of the Great War, and from this work arose the study of the pectin relationships of apple and other juices which were later extensively investigated from the practical and purely chemical standpoints.

Recent Investigations.

It was not until 1932, however, that the utilisation of low grade and surplus fruits was comprehensively studied at Long Ashton. In that year, the writer was appointed to undertake a full survey of this problem in its widest sense. All fruits were included and any products which showed promise of opening up new outlets for fruit were to be examined from the manufacturing and economic points of view. The position regarding surplus and low-grade fruit was serious in 1932, and it was obvious that the problems would become still more pressing as newly planted acreages came into production. This rendered it imperative to evolve economic processes for utilising such material before very large bulks became available. Moreover, the Ministry of Agriculture's grading schemes were beginning to be faced with the inevitable obstacle of the fate of the bulks of fruits which were rejected as being below the standard market grades.

In view of the situation, both as it was then and as it appeared to be developing, advantage was taken of the soft fruit season of 1932 to initiate a preliminary comprehensive programme. Syrups and wines were made on a small scale from all the soft fruits under common cultivation in this country. Heavy syrups were found to be excessively sweet, and the next two season's programmes were devoted to the production of less sweet products. The wines which were made in the initial series, according to the methods adopted in the German fruit wine industry, indicated that several were of distinct promise. Various technical problems concerning the type of sugar, the dilution of the juice, and the extension of fermentation were studied in later seasons, but the difficulties involved in the questions of Excise duty and the expensive process of maturing have not so far allowed extensive commercial developments to follow the experimental work.

The 1934 season brought the introduction of fruit squashes into the programme and, with the improvements in method effected in the following year, recommendations of a reliable nature for their production became available. Commercial production, using entirely the Long Ashton methods, was commenced in 1935 and extended in 1936.

It is, however, in the manufacture of fruit syrups that these more recent Long Ashton researches have been most extensively applied. The growing popularity of milk bars in this country had introduced the need for increasingly large quantities of syrups to incorporate in the milk to produce what are now known as " milk shakes." Preliminary tests showed that fruit syrups made by the Long Ashton cold process gave to the milk shakes flavours definitely reminiscent of the various fruits. The acidity limits to prevent curdling were determined, and in November, 1935, the original syrups, still perfectly sound although three years old, were actually used with great success at the National Milk Publicity Council's Milk Bar at the Imperial Fruit Show at Cardiff.

The favourable publicity conferred on the new products was such that a Bristol firm decided to manufacture the whole range of English fruit juice syrups for milk bar purposes. A factory was established and the writer was enabled, through the courtesy of the firm, to take the work through from the experimental stage to full scale manufacture, and to assume control of the first and second season's productions. In one respect the summer season of 1936 was unfortunate for the new venture. The very heavy and continual series of storms in June and July made the smooth working of the factory difficult, for a steady inflow of regulated quantities of fruit was impracticable, and very much larger bulks of fruit had, at times, to be dealt with than the plant was designed to accommodate. The details of the commercial processing will be briefly referred to in the discussion on Syrups later in this article.

The entire output of the Bristol factory was made with a view to qualifying for the Ministry of Agriculture's National Mark Scheme for Fruit Juice Syrups, which was introduced in June, 1936. After examination and analysis, the entire production was accepted for sale under the National Mark, and the syrups are now being sold on a national scale both to milk bars and to the general public.

The collaboration between the Research Station and the commercial enterprise was extended to cover the 1937 soft fruit season, thus enabling the writer to investigate a number of points which had arisen during the first year's work, and also to travel to the Blairgowrie raspberry area in Scotland and superintend the despatch of experimental consignments of fruit to Bristol.

A still more recent development has been the use of National Mark fruit syrups as a base for high-class aerated beverages. The indications are that a considerable sale will arise from this type of product. As a result of a programme of research work at Long Ashton concerning several technical points arising in the processing of the syrups, *i.e.* the percentages of sugar, acidity and SO_2 necessary for a stable beverage, it became possible to begin commercial production of four aerated beverages of this class, viz. : strawberry, raspberry, loganberry and black currant, throughout the country at the commencement of 1937. It is hoped that a new departure in controlled marketing schemes may be evolved through the medium of the aerated juices. In the scheme now in course of preparation it is proposed that the Ministry of Agriculture should control the quality of the products through a National Mark Scheme, and that the National Union of Mineral Water Manufacturers' Associations should be responsible for fixing prices and ensuring that the agreed prices are maintained.

Following this general survey of the developments to date, the individual products which have been made and examined at Long Ashton will now be discussed.

Fruit Juices.

Two methods are available for the utilisation of fruit in the form of juices. The freshly expressed juice may be treated in various ways to prevent fermentation and be retained in the unfermented state throughout its storage life and until it is consumed. On the other hand, the juice may be sweetened into the form of a syrup (or evaporated in vacuo into a concentrate) and the syrup finally broken down with water into a drinkable beverage. The only fruit juice which is of such a chemical composition that it can be consumed without any considerable alteration is that obtained from the apple. Sufficient varieties of apples of diverse composition exist to enable a suitable acidity to be procured by appropriate blending, whereas the juices from the berry fruits are all much too acid for consumption as such. The latter are most conveniently preserved as syrups or concentrates, which products will be discussed later. The apple is also the fruit which provides by far the largest surpluses.

On the Continent there is a large and constantly increasing demand for unfermented apple juice. The present method for manufacture entails the rough filtration of the fresh juice and its impregnation with CO_2 at 120 lb. pressure per square inch. The heavily charged liquid is stored in enamelled steel tanks until the juice is needed for bottling, when the excess gas is removed, and the juice sterilised by filtration and bottled. The above method, known as the Seitz-Boehi process, has not been examined at Long Ashton on account of the expensive nature of the equipment, but a wide variety of juices have been made by the cold Seitz process and bottled within 48 hours of expressing the juice, or by the alternative method of pasteurisation.

The quality of the finished product depends to a large extent on the nature of the apple used. Kingston Black fruit provides a remarkable beverage, rich and intensely flavoured with the fresh apple character. But there is no prospect of sufficient Kingston Black apples being available to use for this purpose, and the same limitation, though to a lesser degree, is true of cider apples in general. The tannin content of these apples confers a degree of "body" and character on the unfermented beverages which is doubly necessary in a product which does not contain alcohol. Consequently in this connection it is unfortunate that the bulk of the surplus apples in this country are not of the cider type, but of the high-acid, low-tannin, culinary and dessert types. The juices from these apples reflect in their quality the deficiencies of their chemical compositions. It does not appear from the experiments so far completed that the culinary apples by themselves are likely to provide a beverage of the quality of cider apple juice; some incorporation of the more bittersweet types of cider juice can improve the flavour of their juices, and the earlier series of experiments suggested that it was possible that the full utilisation of the type of cull fruit, which is now readily available, would not be accomplished until a supply of bittersweet fruit is available for blending purposes. However, during the spring and early summer of 1937, the special problems of the utilisation of culinary and dessert fruit alone were investigated and a method, involving a special form of maceration, was evolved which enabled Bramley's Seedling fruit to be converted into a remarkably fine, unfermented beverage. The fruit was milled in April and May, by which time the acidity had fallen from about 1.0% to 0.6%.

The results of these experiments have been confirmed by comprehensive investigations during the winter of 1937–8 and, in addition, new methods of improving the flavour and increasing the stability of apple juices have been examined. A special type of apparatus for de-aeration has given most interesting results, and a flash pasteuriser kindly provided by the Metal Box Co., Ltd., without whose collaboration much of the recent work would have been impossible, has indicated that it is probable that a satisfactory alternative procedure to the cold process may soon be evolved.

The winter of 1937 also saw a series of large scale tests carried out on the process of apple juice clarification and stabilisation recently introduced by Dr. Schoop, of Rhinefelden (Switzerland). The tests are not yet completed, but remarkable clarification was obtained by his treatment.

Pasteurised juices are quite different from the cold-processed Seitz-filtered products. The former are heavier in flavour but not so true to the fresh fruit flavour as the cold-processed juices. Flash pasteurised juices are less susceptible to deterioration of flavour than juices which have been given a much more prolonged heat treatment at a lower temperature. Opinion is divided at the moment as to the respective commercial possibilities of the two types. Where intensity of flavour is an attraction, the heated juices will appeal ; but for delicacy and freshness the cold-processed products will always be preferred.

Fruit Concentrates.

The same criticism which has been made in the case of pasteurised juices applies to fruit concentrates, but to a much greater extent. The fundamental idea in concentration is to abstract the water from the juice until the soluble solids content is sufficiently high to prevent fermentation. This entails a concentration to one fifth for apple and black currant, and one tenth for raspberry and strawberry, of their original volume. The high acid contents have a potent effect on the sugars and also, although the temperature of evaporation is reduced by using high vacuum installations, there is, during concentration, an inevitable loss of fruit aroma which it is most difficult to regain. Apple concentrates afford a convenient means of making the maximum use of a glut crop, for storage problems are considerably reduced when dealing with a concentrate. The flavour of " cooked " apples is largely, though not entirely, removed during subsequent fermentation of the broken-down concentrate when converted into cider, but this is not the case when the diluted concentrate is used solely as a base for an unfermented apple juice. Experiments, carried out in December 1937, to determine whether a system of evaporation can be economically achieved which will combine due rapidity of action with relatively negligible spoilation of flavour, have resulted in the production of very attractive concentrates in which the "cooked" taste has been reduced to a negligible degree.

A process whereby the water in fruit juices is removed in the form of ice has been studied at Long Ashton. On a small laboratory scale the results have been most encouraging: provided that the many technical difficulties of working on a large scale and the problem of cost can be overcome, there is no doubt whatever that the frozen concentrates will be of the utmost value and importance in dealing with the surplus fruit problem.

Fruit Syrups.

The fundamental idea underlying the manufacture of concentrates and syrups is the same, *i.e.* the increasing of the soluble solids content to a percentage that inhibits fermentation. In the case of concentrates this is achieved by removing water from the juice, but in the processing of syrups solid sugar is added to the juice until the requisite percentage of solids is attained. Thus a concentrate is a *concentrated* juice, whereas a syrup is actually a *diluted* juice. When this direct contrast in character was first considered at Long Ashton a decision had to be made as to which product was more amenable to improvement. In view of the fact that the syrups were unlikely to suffer deterioration during making if a cold process could be utilised, it was along this line that the studies were continued.

To make a syrup entails, in the first place, a dilution of the juice by the addition of solid sugar, which is followed by a further dilution of the syrup with water prior to consumption. The initial addition of sugar necessary to inhibit completely the onset of fermentation, is, moreover, quite considerable and many advantages would accrue if it were possible to lower the sugar content of the syrup without subjecting the product to the risk of fermentation. By a suitable adjustment of the chemical composition of the juice, combined with the use of SO_2 as a preservative, it has been found possible to make stable syrups with only 50 55% soluble solids and containing 50–57% fruit juice by volume.

A further contribution to the complete method concerned the treatment of the fruit and juice to enable the various processes to be carried out entirely in the cold, and this involved the introduction of a very carefully controlled initial fermentation in which the dispersal of the colloidal constituents of the juice was aided by the use of a commercial enzyme, which exerts a specific action on the pectinous compounds in the juice.

Commercial Developments of Fruit Syrups.

As mentioned in the first section of this article, the Long Ashton method for cold-process syrups was adopted commercially in Bristol during the summers of 1936 and 1937. Over 300 tons of fruit were used, of which 100 tons were strawberries. Unfortunately, it was not possible to make use of any South-West of England fruit, with the exception of black currants, for sufficient quantities were not available at any one time to keep the factory supplied. Most of the fruit was obtained from Wisbech and was received early in the morning (6 a.m.) after an all-night journey by road. The raspberries were mainly bought in Scotland and travelled down in 1-cwt. tubs in 48 hours by train or in 24 hours by road. Loganberries were obtained from Herefordshire, and some bulks of all the fruits, consisting of small and mishapen berries discarded on the sorting belts, were taken from a Hereford canning factory.

At the outset of the venture, it was obvious that there were to be no readily-obtainable surpluses of strawberries and black currants. Indeed, it is generally conceded that strawberries are being under-produced at the present time, whilst a short crop of black currants in 1936 caused a very difficult position with regard to this fruit. From an economic view, it is essential to obtain fruit at equivalent or slightly less than normal jam prices, but in 1936 jam prices were high and the fruit had to be purchased in open competition with buyers for all other purposes. It is somewhat disconcerting to hear reports of considerable wastage of fruit during the very inclement summer which was experienced in 1936, and it can only be presumed that a definite organisation will have to be instituted with the idea of arranging for the collection and despatch to a central depot of all those small lots of fruit which fall into the surplus or ungradable classes.

The fruit arrived, in general, in remarkably sound condition. It is essential that fruit practically free from mould growth should be used, in view of the fact that no heat is utilised in manufacture, and only on one occasion was a consignment of fruit rejected on that score. The fruit was dealt with at an average rate of four tons a day, and the processes were arranged singly on each floor of the five-storey building to enable the partially processed product to fall by gravity from floor to floor.

The processing initially adopted involved the following stages :—Milling the fruit ; slightly controlled fermentation and enzymic removal of pectin ; clarification of juice by centrifuging ; incorporation of sugar and preservative in the cold ; filtration of syrup ;

and bottling of syrup. In the 1937 season preservatives were used, where necessary, to suppress any fermentation, and the pectin was removed entirely by enzyme action. This modification resulted in a decided improvement in flavour in all the syrups. The technical details will not be discussed here as they were fully presented in the Annual Report of the Long Ashton Research Station for 1936 (page 213).

A final total output of over 80,000 gallons of syrups in 1936–7 was achieved. Not only is this factory believed to be quite unique in the world, but it can also be claimed that the processing of such a large quantity of syrup has never before been attempted.

Uses for Fruit Syrups.

The commercial production of syrups was commenced with its main immediate objective of supplying these to the milk bars which are so rapidly increasing in number and popularity in this country. The syrups impart to the milk a very refreshing flavour which is definitely characteristic of the fruit used. With the possible exception of the black currant, all English fruit syrups made according to the above Long Ashton methods can also be incorporated in hot milk, although the final products are not so satisfactory.

Besides their use in milk shakes, the National Mark syrups may be used in a wide variety of ways in the home, and to further this outlet recipe books, which include such diverse uses as water ices, cake fillings, jellies, trifles and cocktail bases, have been prepared for distribution by various firms.

The use of syrups in milk necessitates a careful adjustment of the acidity of the syrup. However, when syrups are to be diluted with water, this limitation is not important and the safeguards conferred on the keeping properties by higher acidities can be adopted. Consequently more highly acidulated syrups are now being used as bases for aerated beverages of the sparkling fruit juice type, and remarkably true flavours are obtainable.

Special reference should be made to the health-giving properties of these syrups. It is only of very recent date that it has been appreciated that amongst fruits the black currant is the most potent source of Vitamin C. (ascorbic acid). The berries themselves contain five times as much of this accessory food factor as orange juice and, whilst a syrup must necessarily contain less than the fresh juice, it still remains a most valuable source. It has not yet been possible to carry out any experiments on the retention of ascorbic acid during storage of a syrup, but work on other products indicates that under normal conditions little loss should be experienced.

Strawberry juice equals orange juice in ascorbic acid content, whilst raspberry, loganberry and gooseberry juice fall below this level. Apple juice itself is not a good source of Vitamin C (in the apple most of this compound is confined to the skin), whilst pears are an even poorer source.

Fruit Squashes.

The first English fruit squashes were made experimentally at Long Ashton in 1934. The aim was to provide a cloudy beverage base which would contain as much as possible of the fine fruit tissue without, however, including the skins and seeds. The many difficulties encountered were not concerned with the flavour of the products, which were invariably more intense than those of comparable syrups, but with the appearance of the products when bottled. The tissue was liable to form a gel in the neck of the bottle, and with fruits such as black currant there was a tendency to get too much solid material in the squash. These disadvantages have been overcome by the incorporation in the squash of a certain quantity of fruit syrup which decreases the concentration of the tissue without reducing the flavour of the squash. Questions of filtration and brilliancy do not arise and the processing itself is simple. One important point, however, must be emphasised. Whereas in syrup manufacture it is possible to obtain a filtered product in which the yeast population is very slight, in the making of squashes it is not feasible to limit by such means as filtration the number of yeast cells present. The tissues passing into the finished product carry numberless yeasts into the squash and special precautions are essential to prevent their development.

Remarkably good squashes have been made at Long Ashton, and the summer of 1936 witnessed the first commercial processing of squashes according to the Long Ashton recommendations by three firms in the West of England and Suffolk.

Fruit Wines.

Home-made wines have long held a reputation for potency and stimulation. Many fine products are encountered from time to time, but there is as yet no recognised standard method for their preparation and no uniformity in composition. Consequently, when the initial experiments on syrups were being arranged, it was decided to begin with a series of wines made according to established German methods. The results were such that an extended programme to elucidate several specific points in the wine-making process was undertaken. Perhaps the most interesting feature of some fruit wines is the way in which the character and flavour of the wine almost imperceptibly changes until it is impossible to appreciate that the product actually originated from the fruit used. For example, with strawberry wines the fruit character was distinguishable during a period of six months of storage but then commenced to change in character, and after two years the flavour resembled sherry rather than a strawberry product. Gooseberry wine tended to change into a hock type, and black currant into a heavy luscious port type, whilst raspberry and loganberry usually retained sufficient fruit character to enable the wines to be named correctly.

The maturing processes are necessary and take time. After two years storage wines are still immature, but even so short a period of maturation as this, adds materially to the cost of the product. This, combined with the excise duty of 1s. 6d. per gallon which is levied on the wines, must tend to make them relatively expensive and prevent their development as commercial products to the same extent and as quickly as syrups.

Apple Products other than Apple Juice.

In addition to the apple juice products already considered, attention has been given to the three following products which have interesting possibilities.

Cider Vinegar.

This product is used throughout the North American Continent. Samples made recently at Long Ashton from a mixture of culinary and cider juices have possessed a most attractive freshness and intensity of flavour. Previously cider vinegars have been made at the Research Station by the slow process of progressive acetification in cask; but in the latest experiments, the quick method, which involves the passage of the cider through a tower packed with beech shavings, is being studied.

Cider Brandy and Commercial Spirit.

A cider of correct type carefully distilled and matured in wood, develops a very fine aroma and flavour, and is highly prized in France where it is sold as Calvados (more prosaically known in England as Apple Jack). Apart from the distilled liquor's use as a spirit it can be rectified and used as commercial spirit. Whether procedure is economically feasible under English conditions cannot be decided until further research work on a semi-commercial scale has been carried out.

Summary.

Investigations of liquid fruit products have been carried out at Long Ashton during the past six years. The more recent work has dealt with the following subjects :—

Apple Juices. Many methods exist for apple juice production. These are described, and a new method, involving deaeration, flash pasteurisation, and a special form of maceration, is also given.

Concentrates. The concentration of fruit juices is satisfactorily accomplished by means of a triple effect evaporator fitted with a device for the separation and collection of volatile flavouring materials.

Syrups. There has been a remarkable development in the production of pure fruit syrups according to the Long Ashton method. The sale of these National Mark syrups has extended to milk bars, ice cream and mineral water factories. The high ascorbic acid content of fruit juices is important in this connection.

Squashes. The products retain to a marked degree the flavour of the fresh fruit.

Wines. Many wines made from English fruits have matured into full-bodied products, which have attractive characters and are of full alcoholic strength.

Other products. Apple brandy, commercial alcohol and cider vinegar can be made from surplus and low grade apples.

THE RAISING OF SETS OF THE CRICKET BAT WILLOW.

By H. P. HUTCHINSON.

Any part of a willow tree is capable of becoming a tree if planted in a suitable place. The planting of living branches cut promiscuously from a tree used to be the common method of propagation, but, as the bat-making industry in its progressive development, continued to demand improvement in sets, both in quantity and in quality, methods of set production, each of which was an advance on the one preceding it, came into existence.

Methods of Producing Sets.

1. Sets from a Pollard Tree.

In this case a healthy vigorous tree is pollarded. The numerous shoots which arise during the following spring are allowed to grow freely for three or four years, when they are cut off close to the bole, the laterals removed and planted out in permanent places. The method has the merit of securing a number of shoots of the required length at little cost in their production, but is open to the following serious objections.

(*a*) Many of the rods are excessively curved at their lower ends and kinked at the places where one year's wood joins that of the next.

(*b*) The side branches which grow from the middle and upper parts of the rod are frequently so thick as to cause serious open scars when they are removed.

(*c*) There is considerable waste due to the number of undersized rods, and to the excessive curvature of the rods which grow on the outsides of the head.

2. Sets Produced from Short Sets.

Under this method, sets about 2 feet in length cut from branches two or three years old, are planted in well prepared ground at regular intervals as in basket-willow culture. The distances between neighbouring plants depend on land conditions and on the length of time of the establishment. Under Long Ashton conditions, where the soil has been shown to be able to produce satisfactory crops for 10 years without the addition of fertilisers (Fig. 3), the most convenient distances have been found to be 3 feet in, and between, the rows.

The simplest method of management of the crop is to allow all the shoots to grow without interference until long sets of the required length can be cut from it, which may be in two, three, or four years. This method is similar to the pollarded tree method, the main differences being in the closer planting and low pollarding, whereby the crop is more conveniently handled, and the growth of side shoots considerably suppressed by the canopy formed by the upper branches.

The objections to this practice are :—

(*a*) The number of undersized and useless rods is often great.

(*b*) The number of well grown sets, *i.e.* sets without kinks and lateral branches, is small.

The Nursery System.

This free grown set method has been brought under a nursery control system of management, the details of which have been described (1). It has the following advantages :—

(*a*) The control which can be exercised during growth ensures that the rod will be straight, without kinks, scars, and other defects which impair the value of the timber in the full grown tree (2).

(*b*) By arranging that the stem when planted shall be multiples of 2 ft. 6 in. in length (the length required for the making of a full-sized bat) no loss of timber need arise.

(*c*) By pruning the leading shoot at the right height and proper time of year a tree with a well-shaped head can be obtained.

(*d*) The greater expense incurred in labour attention is more than balanced by the advantages of obtaining better sets, and in reducing the length of time required to produce them.

A well proportioned set should have the following measurements (Fig. 2) :—

Part in ground for anchorage and root formation	2 feet.
Stem to form the bole of the tree of three bat lengths	8 ,,
Top part of stem to provide branches for making the tree top	2 ,,
Total length	12 ,,

The method has been carried a further stage, towards the object of obtaining annually from the same bed, a supply of biennially grown rods. In order to do so either of the following plans may be adopted.

(*a*) A part of a bed is cut when the rods are one year old ; in subsequent years two-year-old rods would be produced by alternate parts of the bed.

(*b*) To cut part of a two-year-old crop. Two-year-old and one-year-old rods would alternate in succeeding years, except in the first, when part of the crop would be three years old.

Towards the same end it is economically practicable to cut alternate plants in the same row, or to cut alternate rows yearly.

Other modifications of the method which have been tried under experiment during the past four years will be described in due course. In this latest work on the subject the most striking result obtained has been that a considerable advantage is gained by arranging for rods of different ages to grow together on the same head. One year, two year and three-year-old rods grow together in this way to their mutual advantage, but the number of rods of each age needs to be regulated. The best results at Long Ashton were obtained where stools eight years from planting were allowed to grow two rods of each of the three ages.

3. Rooted Sets.

If sets produced by any of the methods just described are planted in suitable soil, roots grow freely and will be sufficiently developed in one or two years to enable the young trees to be lifted and planted in permanent quarters. In practice distances of 18 inches between the plants and 3 feet between the rows have been found to be generally adequate for the carrying out of cleaning and pruning operations and for the development of a substantial root system.

Young trees raised from sets cut from a pollard tree are as defective as the sets themselves in being curved, kinked and scarred, and the trees from nursery raised sets would be equally faulty unless care were taken to give them proper attention during their growth. Only rods of full size in height and girth should be rooted in this way. Undersized and one-year-old rods will root readily but they are unsatisfactory because they are too thin and weak to maintain an erect position especially when new growth adds weight to the tops. Considerable curvature of bole occurs which is further aggravated if the young trees be in a windy situation. If small material such as this is allowed to grow side branches the main stem will thicken, but two or three years would be needed before it became stout enough to support the heads of the trees.

4. The Long Ashton Method.

This method is an extension of the methods already described, and has resulted from the experimental work which has been pursued at this Station for several years. Details up to the present stage of investigation are as follows :—

Soil and its Preparation. A deep fertile soil with an adequate water supply is required. The site should be in full sunlight and protected from strong winds. The preparation needed consists in deeply cultivating, cleaning and fencing the land.

Planting. The sets, which are pieces of stem 10 to 12 inches in length, are cut from healthy shoots two, three, or four years old. The planting distances should be 18 inches in the row and 3 feet between the rows, and the depth such as will secure a firm hold of the bottom end of the set on the *under soil* ; generally about 2 inches of the top protrudes above the surface after the soil has become permanently settled. Planting might be done at any convenient time between the end of October and the end of March.

Management.

Cultivation (*A*) *First Year.* By the middle of May the shoots which will then be about 10 inches in length should be reduced to one which should be strong and conveniently placed. It is important to cut the superfluous shoots and not to tear them off because of the weakening of the hold of the remaining shoot on the stem and the excessive evaporation which occurs at the torn surfaces. The normal growth which follows for the rest of the season, viz., length extension of the stem and the development of lateral shoots, should not be interfered with, but the crop should be observed at frequent intervals in order to repair injuries which may suddenly occur—*e.g.*, in the case of development of a double leader one shoot should be removed ; when death of the tip of a leader occurs a new leader should be brought forward by judicious pruning and training ; any lateral branch developing so strongly as to check the growth of the main stem should be cut back closely ; to prevent Aphis attacks the crop should be sprayed.

By the end of October the season's growth should have resulted in the rods being from 7 to 9 feet in length, erect and well furnished with laterals. In this condition the crop should remain until the following March.

The cultural attention which the soil requires during the first year should be such as will afford good aeration. The best and cheapest method towards attaining this is to keep the land surface in a rough and cloddy condition. By this means the necessity of passing implements through the crops, whereby encouragement is given to weed growth by the resultant fine tilth, together with a too compact condition of the *under* soil, is avoided.

During the winter many laterals, especially those below the middle of the stems, turn yellow and fall off leaving small insignificant scars. Those which persist should be cut off at their bases in March. Some discrimination should be shown in carrying out this operation, the principle to be followed being that only those laterals should be cut where the main stem is considered to be thick enough to attain the required diameter by the end of the second summer. The situation of this pruning cut is important ; it should be limited to the tissue of the lateral only and should not encroach on the tissue of the main stem. This direction always applies to pruning of lateral branches, a very considerable amount of which is needed in later stages of growth. The reason for this procedure is that, by keeping the size of the scar as small as possible, a complete covering by new wood can be secured before the end of the second year, and depressions in the stem exposing the wood, with which dead stem areas spreading from the edges of the wounds are frequently associated, are avoided. A knife in the hands of a careful workman is satisfactory to use, but secateurs set to cut at the right place ensure that, in the hands of a novice, no mistake will be made.

(*B*) *Second Year.* Growth commences in the second year as new shoots from previously formed buds. These shoots are most numerous towards the top of the main stem, and unless they are reduced, would form a low branched head to the tree. To remedy such an occurrence all the top shoots but one should be removed for a distance of about 8 inches down the stem. The shoot retained should be as nearly in line with the main stem as can be arranged ; if, as is generally the case, an angle of growth exists, considerable skill in manipulation is needed to bring the new shoot into the right line.

Subsequent work during the second year should be on the same lines as that described for the first year. Spraying may be needed, lateral shoots should be cut off as soon as that part of the main stem from which they arise is thick enough, and any interference with the growing point should be remedied. All pruning cuts made up to the middle of July heal completely before the end of the season. After that date the wood exposed by pruning fails to become covered, but any loss of moisture is checked by the ingrowths of the new tissues at the margins of the wounds.

As soon as the leading shoot has exceeded a height of 10 feet, which generally occurs in late July, it should be cut back to this point. The effect is to cause stronger growth of the laterals which will become the main branches of the tree. A little attention at this stage ensures the development of a well balanced head.

Trees raised by this method may be lifted and planted in permanent places in October. Fig. 1 represents diagrammatically such a tree. The root system is extensive and as the period of its formation has extended over two years firm planting is possible. The bole is rigid enough to maintain an upright position without the necessity of being staked and being 8 feet in length will give three bat lengths of timber without waste. The top consists of branches capable of forming a well-headed tree.

Sufficient time has not yet elapsed to enable full results to be obtained on the relative values of the two methods in the production of bat willow trees, viz. trees from unrooted sets and trees from young rooted trees, but sufficient information has been gathered to prove these advantages on the side of the latter as follows :—

(1) The defects in the timber being largely eliminated by the care taken in raising the young tree makes it of greater value.

(2) New wood forms freely and plenteously during the first year after planting.

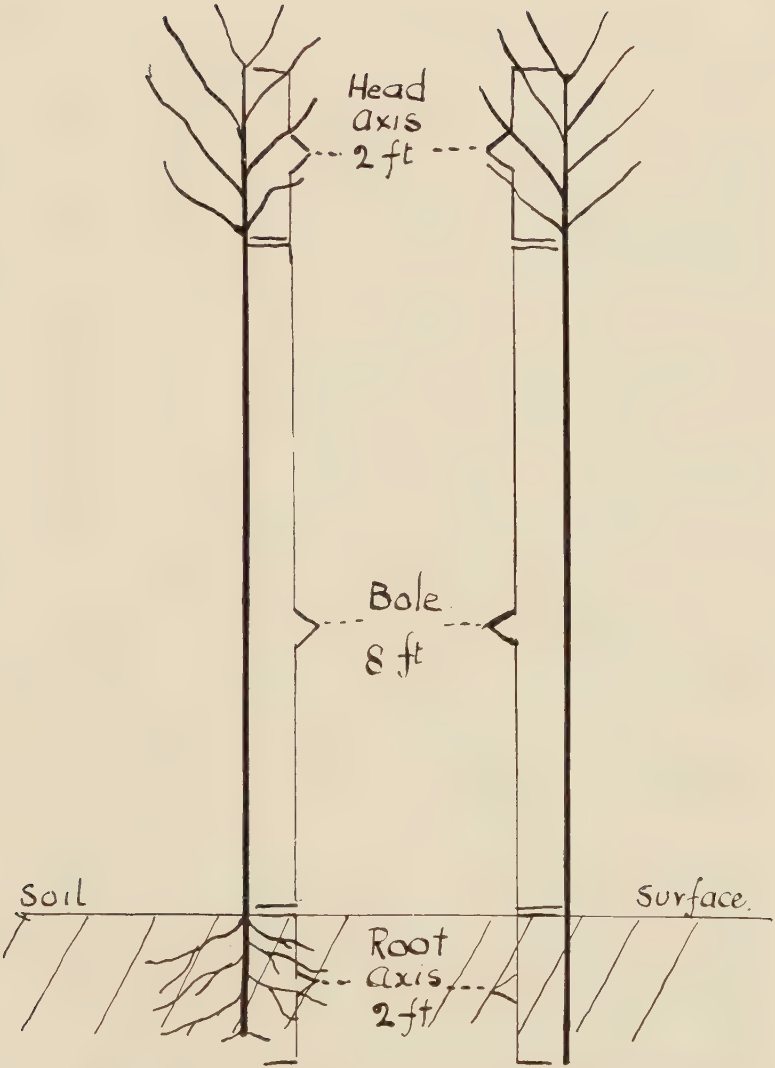


Fig 1. Rooted Set. Fig 2. Unrooted Set.

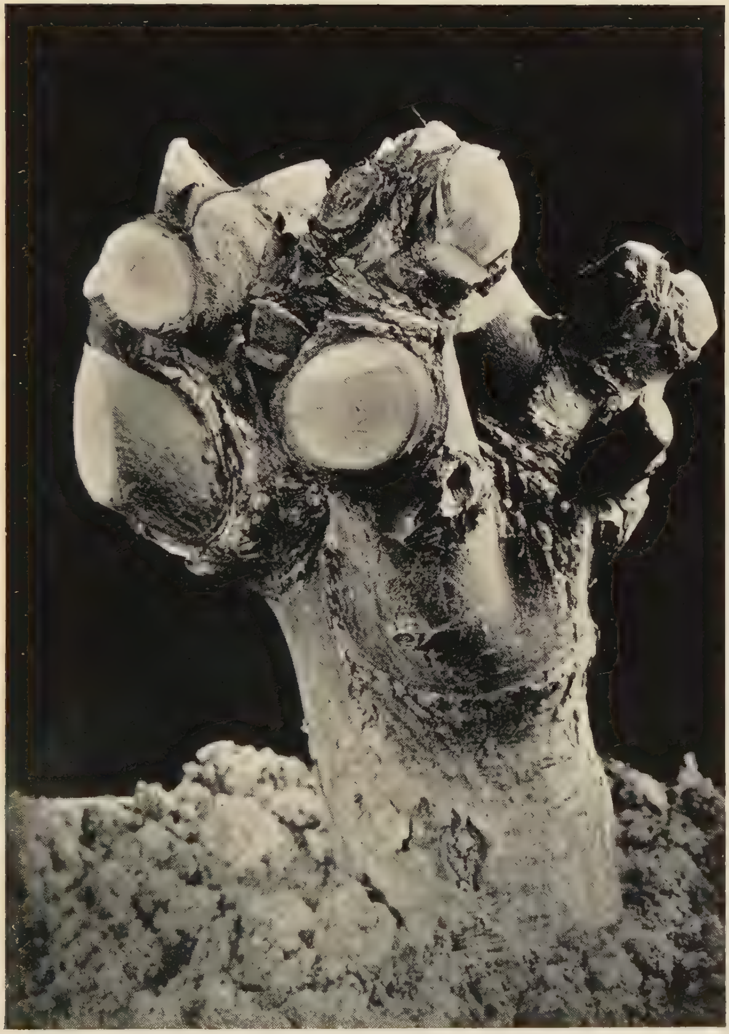


FIG. 3.

Head of Bat Willow Stool ten years old. Five crops of rods have been cut from it. (Scale $\frac{1}{3}$ natural size).

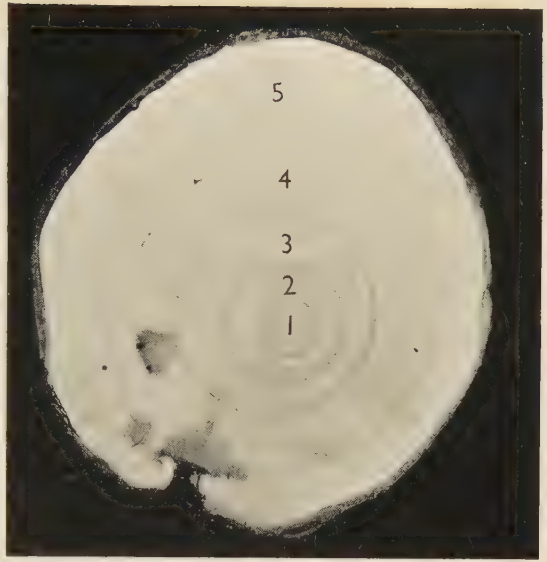


Fig 4.
Section through stem of a five year old tree planted with roots when two years old. (Scale ½ natural size).

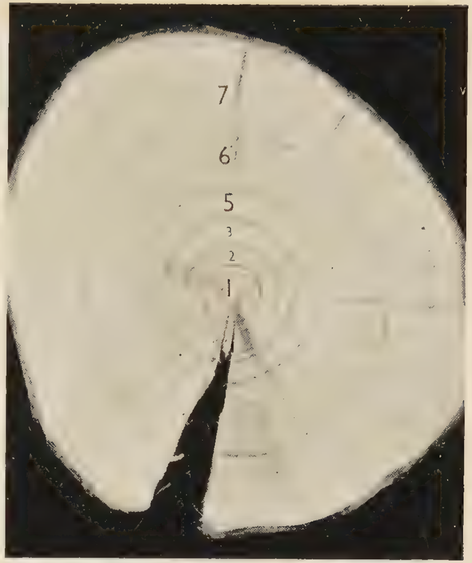


Fig. 5.
Section through stem of a seven year old tree planted without roots when three years old.
(Scale ½ natural size).

Fig. 4 represents a section through the bole of a young tree five years old, which at two years old was planted as a rooted tree. The annual rings show that the amount of increment of growth has been uninterrupted.

Fig. 5 represents a similar section through the bole of a young tree seven years old which at three years old was planted without roots. The narrow ring between Nos. 3 and 5 represents the amount of first year's wood after planting.

(3) The mortality of trees, whether as whole trees or as parts, is low, whereas with unrooted sets heavy mortality frequently occurs.

Summary.

The various methods of raising sets of the Cricket Bat Willow tree are described in a sequence of development from the old practice of planting freely grown branches of trees to the latest system which has evolved as a result of the work done at the Research Station, Long Ashton.

The Long Ashton method, which has as its primary object the production of flawless wood, has been described in detail.

REFERENCES.

(1) Hutchinson, H. P. "The Production of Cricket Bat Timber." *Annual Report Long Ashton Research Station*, p. 215. 1930.

(2) Hutchinson, H. P. "Effects of the Removal and Retention of Lateral Branches in the Production of Sets of the Cricket Bat Willow." *Annual Report Long Ashton Research Station*, p. 231. 1936.

SOIL SURVEYS.

THE SOILS OF THE TEART LAND AREAS OF SOMERSET.

PROGRESS REPORT No. II.

By D. A. OSMOND.

The First Progress Report (1) dealt with the broad outlines of the physiography and geology of the area to be surveyed, and included a short account of the soil series observed in two small areas in the valleys of the rivers Isle and Cam.

Correlation of Soil Series.

The Soil Survey Executive Committee visited the area in 1936 and Table 1 shows the correlations which were established between some of these soil series and those already described in the Vale of Evesham (2).

TABLE 1.

Correlations established between soil series in the Somerset Teart Land Area and the Vale of Evesham.

	Teart Land Area Soils. *Progress Report No.* 1.			*Vale of Evesham Soils.*
(6)	Wyre (?) Series		=	Wyre Series.
(7)	Fladbury (?) Series		=	Fladbury Series.
(8)	Speckington	,,	=	Badsey ,,
(9)	Unnamed	,,	=	Honeybourne ,,
(10)	,,	,,	=	Honeybourne (Shallow Phase) Series.

One series "(12) Unnamed" has since been named the Isle Brewers Series.

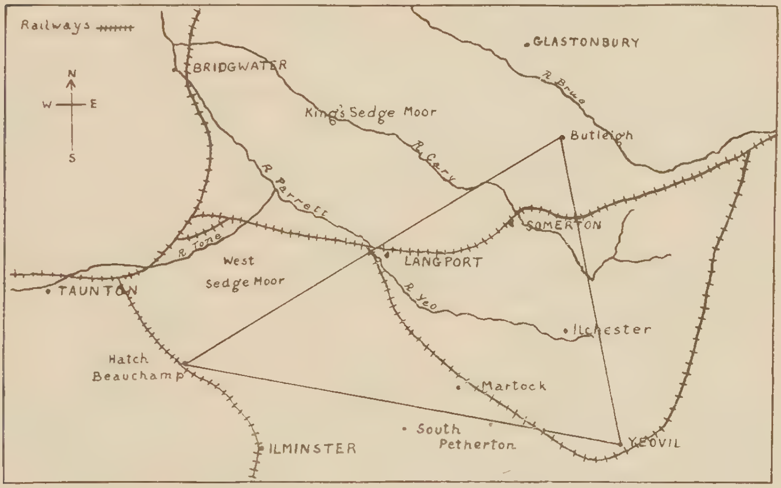
Mapping and Laboratory Work.

During 1936 and 1937 mapping was continued and a total area of 120 square miles has now been mapped on a scale of 6ins. to 1 mile.

The completed maps are available for reference at Long Ashton. The limits of the approximately triangular area, for which maps have been made, are shown in the accompanying sketch-map by lines joining Hatch Beauchamp in the west, Butleigh in the north, and Yeovil in the south.

At the end of 1936 a large area had been mapped and pits were dug and samples collected for analysis. The mechanical analyses of 150 samples are now complete, together with determinations of the calcium carbonate content and the loss on ignition. In some cases the clay fraction has been separated and subjected to chemical analysis.

Sufficient description of the physiography of the area has been given previously (1), but the extension of the detailed mapping has rendered necessary a somewhat more detailed account of the geology.



Sketch Map Showing the Area Surveyed.

Geology of the Area Mapped.

Solid Geology. Within this area the oldest formation shown on the "solid" Geological map is the Keuper, which is generally exposed as a narrow band on the steep slopes facing the modern alluvial deposits of Sedgemoor, Somerton Moor and Butleigh Moor. It includes the Keuper Marl, which gives rise to a red, stoneless clay, the Keuper Sandstone which forms a red sandy soil and the Tea-Green Marl which out-crops on the striking, pale green slopes near Compton Dundon.

The Rhaetic Beds lie above the Keuper Formation and lithologically are closely related to the overlying Lower Lias Formation as both consist of alternating beds of clay and limestone. The Rhaetic Beds form brown clays resting on cream-coloured limestones, whilst grey clays overlie the grey-blue clays and limestones of the Lower Lias Formation.

The Middle Lias Formation is represented by laminated, grey and brown, calcareous, micaceous sandstone which weathers to a brown fine sandy soil. The solid rock is rarely exposed, but it can be seen in a road-cutting near Pass View, Kingsbury Episcopi.

Owing to the scarcity of good exposures of the Upper Lias Formation and the similarity of some of its beds to those of the Middle Lias, this formation has been omitted from the Geological map of the area, but exposures of a rubbly, earthy, light grey limestone, which may be part of this formation, have been noted at South Petherton, Norton-sub-Hamdon, and Hurcot. This weathers to a light grey-brown or warm brown heavy loamy soil.

Lying above the Upper Lias Formation is the Midford Sand, a yellow, calcareous, micaceous and soft sandstone, which readily weathers to a considerable depth, yielding a yellow sandy soil. The solid rock is exposed in several cuttings in the road sides at Compton Durville, Shepton Beauchamp, and Stoke-sub-Hamdon.

Hamdon Hill is composed of Midford Sand capped by Inferior Oolite, which has been extensively quarried. Weathering of this rock results in the formation of a shallow brown clay soil resting directly on the rock.

Superficial Deposits. The "solid" geological formations, over considerable areas, are covered by superficial deposits which are mainly the soil forming material.

At the western end such deposits are almost exclusively derived from Cretaceous material laid down as old river terraces, and are now represented by areas in which flinty gravels appear. Such deposits are found around Hatch Beauchamp, Isle Brewers, Hambridge and Thorney, although isolated patches are found in the east near Kingsdon and Yeovilton.

Generally the superficial deposits in the east consist of waterworn fragments of liassic and oolitic rocks, forming beds of highly calcareous gravel. Such beds are worked at Podimore.

Both the flinty and calcareous gravels are hidden under a more recent silt-clay deposit which varies considerably in thickness.

TABLE II.

No.	*Parent Material. Group.*	*Sub-Group or Remarks.*	*Soil Series.*
7	Clay and Clay Shale, calcareous.	Grey.	*Evesham. *Charlton Bank. †Charlton Mackrell. †Hurcot.
		With limestone bands.	*Haselor. Unnamed (35).
9	Red Clay, calcareous		*Worcester *Worcester (Shallow Phase). Unnamed (C.W.W.)
11	Silt-clay.		*Wyre. *Fladbury. Unnamed (A_2). Unnamed (37). *Isle Abbotts. †Long Load. †Martock.
		Alluvium over peat	†Midelney.
		Thin alluvium on limestone gravel on grey clay	*Badsey. Unnamed (Impeded Badsey).
		Alluvium on grey clay.	*Honeybourne. *Honeybourne (Shallow Phase)
		Wash of cretaceous debris on grey clay.	*Hambridge. *Isle Brewers.
		Wash of cretaceous debris on red clay, calcareous.	Taunton.
12	Sand, calcareous.	Yellow.	†South Petherton.
14	Sandstone, calcareous.	Brown or grey.	†New Cross. †Kingsbury Episcopi. Unnamed (38).
19	Soft limestone.	Grey, flaggy.	Somerton. †Upton.
		Buff, brashy.	†East Pennard. †Bredon Hill.
22	Peat.		†Sedgemoor.

† = Tentative names.
* = Series previously described (1) and (2).

Deposits of material derived from the Middle Lias Formation have been noted round Long Load and Martock, and it is probable that a considerable area south of the river Yeo is covered by material originating from the Midford Sand.

No superficial deposits have yet been observed covering the Midford Sand or Inferior Oolite, although flints, and fragments of of Inferior Oolite are of common occurrence on the former.

Most of the low-lying land in the area is covered by Alluvium which may consist of either several feet of heavy clay or a few inches of clay resting on peat. Some parts of this region are formed entirely of peat, which in general is too wet to be cut, although this is done at Shapwick.

Parent Materials of the Soils.

Table II shows the parent material groups and the soil series which are developed on them.

Soil Series.

The soils have been described on the basis of the profile characters as seen in the face of small pits. Thirty-three soil series have been mapped, of which 12 have been previously described (1), (2), (4). The 21 new soil series are grouped below under their respective parent materials and some of their main features described.

Parent Material Group 7. Clay and Clay Shale. Calcareous.

Evesham, Charlton Bank and Haselor Series are described in (1), (2) and (4).

Charlton Mackrell Series. 12″ of grey-brown, calcareous clay overlying 18″ + of light greenish-grey, highly calcareous clay with a small amount of light brown veining at 18″. Drainage :—Upper layers free, slight impedence at 18″. Of very local extent.

Hurcot Series. 9″ of brownish-grey, or grey stoneless clay which is highly calcareous. This overlies practically unweathered, greenish-grey, calcareous clay containing fragments of hard, pale green marl. Drainage :—Mainly run-off as the series occurs on steep slopes. Very local development.

Unnamed (35) *Series.* 2′ of grey-brown heavy loam or clay containing fragments of limestone, resting directly on broken limestone rock. The clay in the clefts has a yellow colour. Drainage :—Free in the surface, but lower horizon moist. Of very local development. Possibly related to the Haselor Series.

Parent Material Group 9. Red Clay, Calcareous.

Worcester, and Worcester (Shallow Phase) Series, see (1) and (4).

Unnamed (*C.W.W.*) *Series.* 6″—10″ of brownish-red loam or clay overlying red clay with very much grey mottling. Drainage :—Impeded at 18″. Located at the foot of steep slopes fringing the moor-land.

Parent Material Group 11—Silt Clay.

Wyre, Fladbury, Isle Brewers, Badsey, Honeybourne, Honeybourne (Shallow Phase) and Hambridge Series have been described in the previous report (1).

Unnamed (A_2) *Series.* 11″ of brown stoneless, non-calcareous heavy loam or clay with some orange mottling and small black concretions. Drainage :—Impeded at 18″.

Midelney Series. 30″ of stoneless, dark blue-grey clay, non-calcareous, with a well-marked prismatic structure. It becomes gradually darker from the surface, until at 30″ wet clayey-peat occurs. This consists of approximately 45% organic matter and 30% clay. Drainage :—Impeded to the surface.

Unnamed (37) *Series.* 20″ of grey, heavy loam or clay with much yellow mottling, overlying grey clay with much blue, yellow or brown mottling. Drainage :—Impeded to the surface.

Long Load Series. 7″ of brownish-grey or grey, stoneless, non-calcareous clay overlying blue-grey, plastic clay with very much yellow mottling and a well-defined prismatic structure. Under this occurs blue-grey clay with numerous large black concretions. Drainage :—Impeded to the surface.

Martock Series. 18″—2′ of grey, fine sandy clay with some brown mottling, overlying micaceous, fine sandy clay with blue and yellow laminae. Drainage :—Fairly free in the surface, but some impedence at 18″.

Unnamed (*Impeded Badsey*) *Series.* 5″ of brown, non-calcareous, stoneless, clay over 28″ of grey or blue-grey, non-calcareous clay. Calcareous gravel occurs at 3′ or 4′. Drainage :—Impeded to the surface. Rather locally developed. Note :—Cases occur where gravel is not met at 4′, when the series would be Impeded Honeybourne and not Impeded Badsey.

Isle Abbotts Series. Up to 10″ of dark brown stoneless and non-calcareous, heavy sand or light loam, overlying 20″ + of brown and practically stoneless light loam. Drainage :—Free to 24″ and then slightly impeded.

Taunton Series. 21″ of slightly reddish-brown heavy loam with a layer of flinty gravel at the base. Below this occurs 11″ of yellow-brown, slightly calcareous, heavy loam resting directly on slightly calcareous red clay. Drainage :—Some impedence below 2′.

Parent Material Group 12—Sand, Calcareous, Yellow.

South Petherton Series. 6″ of brown, light or heavy sand passing into a considerable depth of slightly brownish-yellow heavy sand which is non-calcareous, stoneless and has no mottling. Drainage:—Free, possibly excessive in some situations.

Parent Material Group 14—Sandstone, Calcareous, Brown or Grey.

New Cross Series. The profile is fairly uniform and has a slightly greyish-brown colour and light loam texture. Some orange mottling and brown concretions occur at 18″. Drainage :—Free in the surface layers but slightly impeded at 2′.

Kingsbury Episcopi Series. The profile is fairly uniform and consists of a stoneless, grey-brown, non-calcareous light to heavy loam. The surface soil has a granular structure. Drainage :—Free in the surface layers, but probably somewhat impeded in the lower horizons. Not as well drained as the New Cross Series.

Unnamed (38) *Series.* Brown, micaceous, light to heavy loam of variable thickness overlying grey, micaceous, fine sandy or silty clay with much brown and some yellow mottling. Drainage :—Free in the surface, but impedence liable to occur at about 10″. Rather locally developed.

Parent Material Group 19—Soft Limestone, Grey, Flaggy.

Somerton Series. 12″ or less of dark brown or reddish-brown, calcareous, clay with a high proportion of limestone fragments, resting directly on cream or buff-coloured limestone rock. Drainage :—Free.

Upton Series. 8″ of dark brown calcareous heavy loam or clay overlying 14″ + of yellowish-brown, calcareous clay which may be slightly mottled. Drainage: -Free in the surface layers but slight impedence may occur at 24″.

Bredon Hill Series. Up to 3′ of warm brown, calcareous, heavy loam or clay with limestone fragments resting directly on broken limestone rock. Drainage :—Free.

East Pennard Series. 6″—3′ of warm brown heavy loam or clay with fragments of rubbly limestone resting on limestone rock. Drainage :—Free.

Parent Material Group 22—Peat.

Sedgemoor Series. 3″—6″ of dark brown or black clayey peat, overlying wet peat. Drainage :—Impeded to the surface.

Future work may show that certain of these series are identical. Thus Unnamed (35) and the Haselor Series may be the same. The Somerton, Bredon Hill and East Pennard Series may be grouped with soils found in the Cotteswold Hills.

Summary.

Soil maps, on a series basis, and on a scale of 6″ to 1 mile, have been made for an area of approximately 120 square miles.

Thirty-three soil series are shown on the maps.

Twenty-one new series are briefly described and are classified under their parent material groups.

Correlations have been established between eleven of these series and series previously recognised in the Vale of Evesham, Worcestershire.

REFERENCES.

(1) A Survey of the Soils of the Teart Land Areas of Somerset. Progress Report, No. 1, D. A. OSMOND. *Ann. Rept. Agric. and Hort. Res. Sta., Long Ashton.* 1934.

(2) A Survey of the Soils and Fruit in the Vale of Evesham, with Special Report on Vegetable Crops. Summary. T. WALLACE. *Ann. Rept. Agric. and Hort. Res. Sta., Long Ashton.* 1936.

(3) List of Parent Materials. Soil Surveyors Conference. *Paper No.* 38. April, 1936.

(4) A Survey of the Soils of the Long Ashton Research Station Farm. D. A. OSMOND. *Ann. Rept. Agric. and Hort. Res. Sta., Long Ashton.* 1936.

REPORT ON ADVISORY WORK, 1936-1937.

The actual number of enquiries shown in the statistics for 1937 for the Department, which are directly comparable with those of 1936, shows a slight decrease when compared with the latter year (—33) in a total of 6,453, so that the volume of advisory work may be considered as very similar in the two years. Nor do the amounts of work recorded under the various sections show much change in the two years, only in three cases of the fourteen for which statistics are included are there differences exceeding 100, viz. :—Dairy Bacteriology (—197) and Cider (—116).

As in previous years no statistics are included for Agricultural Economics, where the work shows considerable expansion, as is evident from the volume of correspondence in this section, nor for the Poultry Pathology service in connection with blood testing and post-mortem examinations. In the latter section the numbers of blood tests show a considerable decrease for 1937, 85,044 tests being made as against 98,902 in 1936. The decrease is attributed by the Pathologist to the adverse economic conditions within the industry. On the other hand the number of pathological specimens received shows an increase during the year of 192.

The statistics presented in the table below refer to fourteen subjects, four of which are in connection with the work at the Berkeley Square Centre, whilst ten relate to work at the Long Ashton Institute.

At the Berkeley Square Centre there is a nett decrease of 29 enquiries, due solely to the decrease in Dairy Bacteriology, the other three subjects showing increases, viz. : Agriculture and Agricultural Chemistry (+78), Veterinary Science (+44), Poultry Pathology (+46). Though the Dairy Bacteriology Section shows the above decrease in enquiries it should be noted that the decline does not signify a falling off in the amount of work, since 14,521 samples were examined in 1937 as against 11,898 in 1936. The work in this Section is subject to periodic re-orientation which makes comparisons of strictly advisory samples somewhat misleading as a guide to the volume of work.

The Long Ashton subjects show an insignificant change (—4), the figures for the various subjects being as follows :—Cider (—116), Cider Instruction (+24), Fruit Products (+13), Pomology (+37), Horticultural Chemistry (+10), Economic Entomology (—5); Economic Mycology (+8), Insecticides and Fungicides (+16), Domestic Preservation (+34), Willows (—25).

The only notable change is the decrease in Cider. This is accounted for almost wholly by a falling off of enquiries from areas outside the Bristol Province and seems to be mainly due to cessation of requests regarding the problems of utilising commercial varieties for cider making.

It may be noted that the volume of advisory work for the past three years has shown little change, development occurring in certain directions and changes in the character of work occurring in one or two sections. The maintenance of the work calls for considerable effort from the officers responsible for the various sections, this being especially so where research officers are also called upon to undertake advisory duties.

In the Fruit Products work at Long Ashton it is pleasing to be able to report that the officer in charge of the section has once more supervised the season's production of fruit products in the factory of Messrs. H. W. Carter & Co., Ltd., Bristol. The two seasons of co-operative work between the Department and the Firm have been of great benefit to both parties, and have done much towards establishing the Fruit Products Industry on a sound scientific basis.

In Pomology the problem of visitors to Long Ashton continues to throw much work on the pomological staff, whilst in the Insecticides and Fungicides section it is gratifying to note the close co-operation which is maintained between the officer in charge of the section and manufacturers of spray materials. Under Cider Instruction, the three Counties of Dorset, Monmouth and Worcester have all participated in the scheme for the whole year. The Instructor has continued to give attention both to farm cidermaking and to farm orcharding.

The advisory work in the present report is classified under fifteen heads, viz. :—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Fruit Products, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables, and Willow Growing.

The statistics which are given relate to all subjects excepting Agricultural Economics where the method of working does not lend itself to statistical tabulation of enquiries as a means of assessing the work, since the personnel of the section concentrate on special problems of groups of farmers and on economic surveys of farming methods and special rural industries, and normally only consider the special cases of individuals as they arise in group and survey studies.

Under Poultry Pathology, the main work of the laboratory is not included, but only enquiries which are dealt with by the Poultry Pathologist on behalf of the Veterinary Investigation Officer.

The numbers of enquiries submitted to the Department during the past six seasons are summarised in the following table :—

	Year ending September 30th.					
	1932	1933	1934	1935	1936	1937
Gloucester (including Bristol) ..	871	849	945	1602	1622	1730
Hereford	169	310	337	360	497	275
Somerset	578	810	997	1119	1138	1118
Wiltshire	343	481	476	1365	848	1007
Worcester	399	455	496	528	509	360
Other Areas	960	1217	1562	1571	1872	1963
	3320	4122	4813	6545	6486	6453

The figures are shown separately in the table for the five counties which comprise the Bristol Advisory Province and for Other Areas. In this latter category are included enquiries from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute. These counties do not rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Province for advisory purposes relating to Horticulture, whilst close touch is maintained with the personnel of both Counties through the medium of the Horticultural Sub-Committee of the Provincial Advisory Council.

The data do not include the numerous enquiries dealt with in personal interviews, during survey work, local investigations, Shows, etc.

The following features referred to in the sectional reports which follow call for special mention :—

Agriculture and Agricultural Chemistry.

A further increase in the volume of advisory work under this head is recorded and as the result of a slight increase in the advisory grant in connection with travelling, it has been possible for some 331 advisory visits to be made.

Apart from the normal routine enquiries concerning crop failures and livestock problems, an appreciable number of samples were received from industrial concerns with a view to report as to their agricultural value either as fertilisers or as feeding stuffs.

In the case of samples of water, these were received from farmers who were investigating new sources or attempting to improve their present supplies. In one or two instances the samples of water submitted were from sources which were reputed to be causing illness amongst farm stock.

On the investigational side, two new " long range " investigations have been commenced ; one to determine the variation in the nutritive value of hay produced under different conditions in the West Country, and the other to examine the " lime value " of high and low phosphatic slags on acid grassland. The Advisory Centre is indebted to the Bath and West Society and to the British Basic Slag Corporation for generous grants in connection with these investigations.

The study of the influence of poultry on the chemical composition of grass and soil was completed during the year under review and the results published in the Journal of the Ministry of Agriculture.

The series of broadcast talks " For Western Farmers in Particular" is still being continued, and a very large number of contacts with West Country farmers and growers have been made as a result of these talks.

Dairy Bacteriology.

The work of this section has remained steady during the year. The number of requests for advice was slightly less than in the previous year, but the total number of advisory samples examined exceeded the 1936 figure.

A further Clean Milk Competition was conducted in Worcestershire, and the Wilts Milk Testing and Advisory Scheme was again organised on the same lines as for the previous year. It is hoped to arrange for an advisory scheme to commence shortly in Worcestershire.

The Advisory Centre is still responsible for the examination of official graded milk samples submitted by the County Councils of Wiltshire and Gloucestershire.

Investigational work on the value of the Methylene Blue Reductase Test was continued in collaboration with the National Institute for Research in Dairying, and other Advisory Centres.

Agricultural Economics.

A considerable increase in work was recorded, largely on account of the new Farm Management Survey. This is a national investigation in which all Advisory Centres are co-operating. Altogether, Bristol surveyed 150 farms of various sizes and types, covering an area of nearly 45,000 acres.

The work of ascertaining the cost of milk production for the Milk Marketing Board was continued, and the results for the third year have been tabulated and forwarded. This enquiry is yielding a large amount of valuable material not only for research purposes but for advisory work among farmers. A feature of this work has been the individual farm analysis of feeding methods ; this has been greatly appreciated by the farmers concerned, since it gives them a very close insight into their feeding methods and costs.

It has not been possible to expand the special investigations into pig and poultry management, but the usefulness of these enquiries is patent. The information collected in the course of the pig enquiry has enabled data to be forwarded to the Bacon Development Board.

Interest in the Wiltshire Agricultural Accounting Society is as strong as ever. The membership increased during the year by 19, so that there are now 61 farmer-members, all of whom take an active part in the Society's meetings and discussions.

Veterinary Science.

A continued increase in the number of requests for advice on the many problems connected with the diseases of domesticated animals is recorded.

The number of pathological specimens representing all classes of livestock received at the laboratory for examination has been maintained during the year.

Parasites continue to be the chief cause of losses among sheep. A number of severe outbreaks of Liver Rot occurred in the spring. The developmental stage of the flukes pointed to a continued infestation carried into late autumn and in several instances up to 5 c.c. carbon tetrachloride were administered with good results.

Blood agglutination tests for Contagious Bovine Abortion have been performed in a number of herds and the eradication or segregation of reactors carried out as an aid to control. Other investigations on conditions affecting cattle have been conducted with regard to Mastitis, Johne's disease, parasitic gastritis of calves, etc.

Pig Pox, formerly rare in England, has been widespread in the Province during the year. Anaemia of small pigs has been particularly troublesome on one farm in spite of good surroundings, and the work so far carried out suggests that heredity may play a large part in susceptibility of piglets to this condition.

Poultry Pathology.

The year under record has not shown the same steady advance as have the previous ones. An increase in the number of pathological specimens and requests for advice has been recorded, the former totalling 1,762 and the latter 160; the number of blood samples, however, has shown a marked decrease to 85,044.

In assisting the Veterinary Investigation Officer, 88 visits were made to poultry farms in the Province.

All the more common diseases have been met with in the examination of adult carcases, including Coccidiosis, parasitic round and tape worms, Tuberculosis, Neuro-lymphomatosis and Infectious-entero-hepatitis.

Three outbreaks of Infectious laryngo-tracheitis and two outbreaks of Fowl Cholera were diagnosed.

Amongst chicks, mismanagement (chilling or overheating), Pullorum disease (Bacillary White Diarrhoea) and caecal coccidiosis in that order of frequency, have been responsible for the majority of losses.

Six outbreaks of disease in chicks involving heavy losses were found to have been due to infection with B. typhi-murium. Rickets and leg weaknesses of chicks have been more prevalent.

Economic Entomology.

The number of enquiries regarding Agricultural and Horticultural pests showed little variation from the previous year, and there was no outstanding or wholesale infestation.

The spray programme service dealing with the control of fruit pests was extended with the co-operation of the Provincial Agricultural Authorities. Counties outside the Province and manufacturers of spray materials availed themselves of the information distributed by the local press and leaflets.

Plum Sawfly infestations were of exceptional severity throughout the Province. Field trials again demonstrated that a carefully timed application of a wash consisting of a white oil emulsion and a rotenone-containing material provided a satisfactory control.

Fruit Tree Red Spider has become established as the major pest of apples and plums in many orchards. Control measures have been investigated and no difficulty should be experienced in obtaining a high control of the Spider infestations.

Considerably more interest was shown in the use of post blossom emulsions containing white oil as advocated by Long Ashton.

The mite *Tarsonemus spirifex*, recorded from Gloucestershire in 1912, damaged a 20 acre oat crop in Wiltshire and also occurred in Somerset.

" Strangle " in Mangolds was more than usually prevalent and needs further elucidation.

The Gout Fly of Barley, *Chlorops taeniopus*. was of widespread recurrence. Further plot and pot trials yielded no support to the view that the Oat Eelworm *Anguillulina dipsaci* is transmitted by seed, but further evidence was obtained regarding the importance of weeds as host plants.

Field trials with calomel as a control for the Cabbage Root Fly *Chortophila brassicae* were commenced, and the use of pyrethrum emulsions for the control of *Calandra granaria*, the Granary Weevil, was continued.

Economic Mycology.

The number of advisory enquiries dealt with by letter was 498, compared with 490 last year.

Mr. C. J. Hickman continued to serve as Assistant in Vegetable Disease Investigations. Mr. D. L. G. Davies, a post-graduate student, continued his work on *Fusarium* diseases, whilst Mr. E. H. Wilkinson, a graduate of Birmingham University, commenced post-graduate work on " Apple Fruit Rots and Spots."

J. G. Horsfall of Geneve (New York) Experiment Station, U.S.A., has introduced in that country the use of cuprous oxide and of zinc oxide as seed protections, *i.e.* to prevent rotting of the seeds below ground, or pre-emergence damping off, owing to soil organisms. During his visit to Long Ashton in the winter of 1936-1937 the opportunity was taken of trying out these substances under English conditions, and this work has been extended by field trials and further greenhouse experiments.

Four field trials of dwarf beans were laid down. Seeds of 40 varieties were obtained through the kindness of seedsmen and observations were made on the following points : (1) morphological characters and classification, (2) earliness, (3) market value, (4) yield, (5) resistance or otherwise to halo blight, anthracnose, mosaic, etc. The resistance of certain varieties to halo blight was confirmed and other varieties were also shown to be resistant. Strains of dwarf beans apparently resistant to foot rot (*F. Solani.* var. *Martii*) were further bred up. Strains resistant to halo blight and anthracnose were received from abroad.

A trial of 11 varieties of winter lettuces was laid down with the co-operation of Mr. E. W. Hobbis, Horticultural Instructor for Worcestershire. This and the previous trial in the winter of 1935-36 are reported on in the Worcestershire County Quarterly Agricultural Chronicle for August, 1937. The trials gave valuable information on the relative survival of winter lettuce varieties.

A bacterial disease of winter-flowering Begonias, which causes much loss to growers of these plants, is being examined in co-operation with W. J. Dowson and W. C. Moore.

Willow Growing.

The demand for good quality basket willows has been maintained and the price of rods has continued to rise.

Sets of the Long Ashton hybrids have been asked for by commercial growers in carrying out their planting programmes, and sets of the most suitable hybrids have been sent to Kenya with the object of growing rods for making baskets needed in Tea Culture.

Bat willow growing is spreading rapidly throughout the Country. The improvement in the quality of timber made possible by the work on Set production at Long Ashton has been fully recognised, and commercial growers now follow the methods devised at the Station.

The salient features of the work of each section during the year are summarised below :—

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

The steady increase in the volume of advisory work reported previously has been maintained during the year under review, and again appreciation must be recorded of the co-operation and whole-hearted support of the County Agricultural Organisers in the Province and the members of the Staff of the Department of Agriculture and Horticulture of the University.

As in former years, specimens of weeds, herbage plants and rocks have been received for the purpose of identification and report as to commercial value, poisonous properties, etc., and the valuable assistance rendered by the Departments of Botany and Geology in the University in connection with this work is gratefully acknowledged.

During the year ended September 30th, 1937, 960 requests for advice were received, which is an increase of 138 over the previous year, and 331 visits were paid by the Adviser and his assistants.

The number of samples examined in the laboratory totalled 964, of which 584 were advisory and 380 investigational.

A few notes on some of these samples are appended :—

Advisory.

Soils.

The majority of soils submitted were concerned with problems of manuring or of crop failures.

The Land Fertility Scheme was responsible for a considerable increase in the number of soil samples received.

Fertilisers.

The fertilisers received were by-products from various local industries, and were sent in for opinion as to their manurial value.

Limes and Limestones.

A number of the limes and limestones received were from farmers who have limestone rock on their farms and were desirous of knowing whether the material was suitable for grinding and application to soils. A few waste lime products were also submitted for opinion.

Feeding Stuffs.

Of the foodstuffs received for examination, a large number were suspected of being injurious or causing digestive troubles in animals. In only a few cases was it possible to substantiate such beliefs. Quite often, however, the receipt of the food resulted in advice being given upon the method and system of feeding which obviated the source of the trouble.

Herbage.

One consequence of the increased interest taken in grass drying in the Province is reflected in the large number of herbage samples analysed. In some cases advice was also given upon the methods of feeding dried grass.

Samples of hay were also received for opinion upon the feeding value for various classes of livestock.

Water.

Of the water samples received, the majority were from farmers who are seeking new sources, or attempting to improve their present supply.

In a few cases the samples were of water suspected of causing illness to animals.

Poultry and Grassland.

The publication in the Journal of the Ministry of Agriculture of an article on the effect of poultry on the soil and herbage of grassland has stimulated the interest of poultry farmers in their grassland, and a number of requests for advice have been forthcoming.

The results of a trial with folded poultry on acid grassland indicate that, when the land is limed. poultry can effect an improvement in the herbage fully equal to that obtained with basic slag.

Investigational.

(a) Grassland.

(1) *Nitrogen and Mineral Uptake of Herbage.*

The field work in this experiment has now been finished, and it is hoped to complete the laboratory work and report upon the results in the near future.

(2) *Dried Grass.*

Investigations have been carried out to test the efficiency of the various grass driers in the Province. Botanical and chemical analyses were also made for the purpose of testing the type of product.

(3) *The Composition of Hay.*

An investigation of the composition of hay produced in the West of England and of the factors affecting its quality was commenced in February 1937. The preliminary work has been concerned with the variation in the composition of hay within the stack, and with the development of a convenient and accurate technique of sampling in the field and laboratory. This investigation is being carried out in collaboration with the Education and Experiments Committee of the Bath and West Society, and a special grant has been made by the Society for the work.

(4) *The " Lime Value " of Basic Slag.*

An experiment designed to determine the lime value of high and low phosphatic slags on acid grassland was commenced in March 1937. Particular attention is being paid to the effect of the slags on the lime status of soil and herbage, but the opportunity will be taken to obtain all possible information concerning the effects of lime and slag on acid grassland.

A special grant from the British Basic Slag Corporation has been made to the Department towards this investigation.

(b) Arable Land.

(1) *Sugar Beet Factory Waste Lime Experiments.*

Experiments with this material which are being carried out jointly by the Harper Adams and Bristol Provinces were continued at the same centre as last year, the crop during the present year being sugar beet.

(2) *Fertiliser Value of Dried Poultry Manure. Ministry's Scheme of Field Experiments.*

The interest of West of England farmers in dried poultry manure has fallen away, and consequently the experiments were conducted at one centre only (Yeabridge, Somerset) in 1937. The trials will be continued at this centre for three years.

Plans for experiments on horticultural crops in 1938 are under consideration.

General.

Agricultural Shows.

Exhibits were staged at the more important shows in the Province. The Adviser and members of his staff were present at these shows and dealt with enquiries. Once again the co-operation of officers of the Ministry of Agriculture and Fisheries in staging the exhibit at the Bath and West Show, Trowbridge, is gratefully acknowledged.

Broadcasting.

Forty-seven evening broadcast talks to farmers were given in the West of England and National Programmes. Other Advisory Officers attached to this centre and research workers from Long Ashton Research Station, as well as farmers and growers, participated in these talks.

Lectures.

The usual course of lectures in Agricultural Chemistry was given to the B.Sc. (Agric.) degree students in the University by the Assistant Adviser.

In addition, seventeen lectures were given to outside bodies on a variety of subjects, five of the lectures being under the Extension Lecture Scheme of the Ministry.

DAIRY BACTERIOLOGY.

During the year the number of samples of milk and milk products submitted for examination from all sources was 14,521. The requests for advice totalled 1,241 as compared with 1,438 for 1936, and 64 advisory visits were made.

The decline in the number of requests for advice was not unexpected. It was due entirely to the fact that the great demand for advice on milk production methods which resulted after the introduction of the National Accredited Milk Producers Scheme in 1935 has now fallen to a slightly lower level, as most of the milk producers with reasonable facilities for the production of graded milk have now obtained their licences.

Competitions.

In collaboration with the County Agricultural Organiser, the twelfth annual clean milk competition was conducted in Worcestershire, and once again proved to be very successful. The Gloucestershire Milk Recording Society held its second annual clean milk competition, and the third competition was commenced.

Organised Advisory Schemes.

The Wilts Milk Testing and Advisory Scheme has been continued with 129 members. As the Methylene Blue Reductase Test is now used as a test for official grading purposes, it has been introduced in addition to the plate count and presumptive coliform test for all Advisory Scheme samples.

Efforts are being made to organise an Advisory Scheme in Worcestershire.

Under the Advisory Scheme in Gloucester, the object of which is to give advice to graded milk producers who obtain unsatisfactory bacteriological reports, many samples have been dealt with in the laboratory, particularly during the warm summer months.

Private Samples.

Farmers, chiefly producer-retailers, and the trade have continued to make use of the facilities offered at the provincial laboratory for the examination of private samples. The reports on these samples are for the private information of the senders. They show whether the technique of production, handling and processing is of a satisfactory standard.

Official Graded Milk Samples.

While County laboratories now deal with all official samples from three counties in the Province, the examinations for Wiltshire and Gloucestershire are still conducted by the University at this Centre.

The percentage of samples failing to attain graded milk bacteriological standard was slightly in excess of last year's figure. The higher prevailing atmospheric temperature was undoubtedly a prime cause of this increase, as is shown by the fact that no less than 84% of the failures occurred during the summer period.

Special Advisory Work and Investigations.

Advisory samples arising from the advisory schemes and the production of graded milk have again been numerous, but fewer cheese problems have come to the notice of the Dairy Bacteriologist.

In solving problems relating to milk production, the duties of the Dairy Bacteriologist are becoming more and more technical and often necessitate visits to the farms concerned. Extensive use has been made of sterile water for rinsing dairy plant in order to trace obscure sources of bacterial contamination.

Generally speaking, rural water supply samples examined during the year, have again shown disappointing bacteriological results; in many cases it has been necessary to report that the supplies are potentially unsafe for drinking purposes, and also unsatisfactory for dairy requirements.

Methylene Blue Reductase Test.

Experiments were conducted as follows :—

1. To determine the value of the Methylene Blue Reductase Test as a substitute for the plate count test for the commercial grading of milk, and to observe the relation between the bacterial count and the reduction time of bulk milk samples.

The following points are indicated from the results :—

(*a*) When a large number of samples is considered there appears to be a fairly good correlation between the plate count and the reduction time, and there seems no real grounds for condemning the reductase test for the purpose designed.

(*b*) The reductase test, in itself, gives no noticeable indication of the degree of contamination due to coliform organisms unless it is extremely abundant.

(*c*) At least some types of *mastitis streptococcal* infection, and also other less common species of micro-organisms likely to be present in milk have either only a feeble reducing influence on methylene blue dye or produce no effect. In several cases of sub-clinical or latent mastitis infection, when large numbers of the causative organisms were present in the milk and the cellular content of the latter was normal, reduction of the dye was found to occur only very slowly.

2. To determine the reproductability of the Reductase Test and the Plate Count in different laboratories and by different workers when standardised technique is employed.

Fifty samples have already been examined and the work is being continued for a further period in collaboration with three other Advisory Centres.

AGRICULTURAL ECONOMICS.

Enquiries and Advisory Work.

Both the number of letters and the number of farm visits show a considerable increase over the previous year, and a great proportion of this increase is due to the commencement of the new Farm Management Survey Scheme. Altogether 4,290 letters of various kinds were sent out as compared with 2,502 in the previous year. It is interesting to note that there were a number of enquiries from large farmers asking for advice in instituting a full cost accounting system on their farms.

The number of farm visits increased from 389 to 579.

Investigations.

Surveys.

The only survey which has been carried out during the year under review is the new Farm Management Survey.

One hundred and forty-three farm accounts were obtained, the total acreage amounting to 44,873 acres.

These farms have been divided into four groups:—The first group consists of 52 farms in which the proportion of arable is 25% or above. The second group includes 52 milk farms where sales of milk account for 50% or more of total sales. The third and fourth groups comprise 19 cheese-making farms and 20 mixed farms respectively.

The data have been tabulated both in the aggregate for each group and on the 100 acre basis. All groups showed a profit margin; the large arable farms have fared worst and the small cheese-making farms best. The per 100 acre figures clearly show the intensiveness obtaining on the cheese farms. Pig production plays a prominent part in this group and in the group of 20 mixed farms. The second year's survey is now in progress, and it is hoped that over 200 farmers will furnish the requisite data.

Enterprise Studies.

Cost of Milk Production. The investigation into the cost of production of milk, undertaken on behalf of the Milk Marketing Board, has now completed its third year. From time to time a number of farms have dropped out of the scheme. These have not been replaced since the number of farms still recording is up to the quota required by the Milk Marketing Board. Thus in the report for the previous year the costs from 110 farms were tabulated, but in the present year there are only 92 costs available.

The average cost of production worked out at 9½d. and 9¼d. per gallon in 1935 and 1936 respectively. The total number of cows on all these farms was 4,154 for the year 1934–5 and 3,367 for 1935–6.

A considerable amount of research has been carried out during the year into questions of feeding and a short note is given by the following paragraph.

Research into Milk Costing. It is found that whilst summer yield is generally higher than winter yield, the bulk of the increased summer yield occurs in May. The summer period contains not only the week when yield is at its highest, but also the week when yield is at its lowest. Thus a special problem is created, when, as the lactation proceeds yield declines when the feeding quality of grass is also reduced.

A summary of the weekly changes for the year in question is provided by the following table, the starch deficiency method being employed to ascertain the relative importance of grazing : –

Mid-week of	*Grazing.* %	*Hay (etc.)* %	*Concentrates.* %
October	55	13	32
November	33	29	38
December	15	42	43
January	7	47	46
February	2	51	47
March	1	51	48
April	26	34	40
May	74	5	21
June	80	2	18
July	82	1	17
August	77	2	21
September	70	3	27

This table quickly reveals the special problems of particular months (or groups of weeks). The amount of grazing in 1934 penetrated well into November, accounting for 33% of total requirements in the middle of the month. The problem of winter grazing is primarily a problem of November and in lesser degree of October and December. It was during November 1934 that the hay ration reached half the winter maximum. The date at which hay reaches half-maximum varies from season to season and from farm to farm, but it is necessary to emphasize that this is the kind of factor which requires special analysis.

Weekly data have made it possible to analyse the total feeding in the following manner for the complete year :—

Class of Foodstuff.	*% of Total in Terms of Starch.*	
	Production.	*Maintenance.*
Grazing	7%	37½%
Hay (etc.)	0%	24 %
Cake	29%	2½%
	36%	64 %

Grazing accounts for 44½% of the total feeding, but less than one-sixth is used for milk production. Grass provides for maintenance from April until October in considerable quantity, and from November to January in diminishing quantity. It also provides for more than one-half the production ration from May to July, for less than one-half in August, and for a very small fraction subsequently. Hay, in the mid-winter period of February and March, provides inadequately for maintenance, being made good by cake. Hay feed rises to about 20 lbs. per cow per day, but its feeding value can be demonstrated to be below average (starch equivalent 29.6%). Cake, on the other hand, is fed in excess of requirements from the end of November to the beginning of April, assuming a liberal standard of 4 lb. to the gallon. The feeding of cake rises to nearly 5 lb. to the gallon during February and March. Even when liberal standards are allowed, the value of summer grass for the milk production ration is more than half offset by the winter feeding of cake for maintenance.

Pig Management. The inquiry into the methods of pig management which was referred to in the report for last year, has been continued. Considerable attention has been paid to the collection of data beyond those which may be termed purely or directly financial. Thus farrowing records, housing conditions, grading records, boar performances have all been analysed.

In fifteen herds of varying sizes there were 472 litters during the year, and a total of 4,109 pigs were born alive. Of these 568 died before weaning, so that the loss was nearly 14%. The weaning average came out at 7.5, with a range from 9.8 to 5.9 weaned per litter.

In addition to the 568 pigs which died before weaning, 302 were lost between 8 and 16 weeks and 35 over 16 weeks old, thereby making a grand total of 905 deaths. In only 400 cases was it possible to obtain the specific cause of death.

Apart from porkers and miscellaneous sales 2,250 pigs were sent to bacon factories and the grading results were as follows :—

Grade.	*No. of Pigs.*	*Per cent.*
A	414	18
B	532	23
C	744	33
D	319	14
E	27	1
S	62	3
Under Weight	92	4
Other Accepted Pigs ..	60	3
	2250	100

Poultry Farming. The inquiry into the economics of poultry farming has been continued during the year and individual reports sent to the farmers co-operating.

Lectures.

The usual course of lectures was given in Agricultural Economics and in Statistics to the Pass and Honours Degree Students in the Department of Economics. In addition six evening lectures were given to various bodies in the Province.

VETERINARY SCIENCE.

Enquiries and Advisory Work.

During the period under review 476 requests for advice were received, 597 specimens examined in the laboratory and 138 visits were paid to farmers in the Province.

Many of the more common diseases affecting the domesticated animals were encountered. Among cattle, contagious abortion was commonly the subject of enquiry and blood testing on a number of farms has been carried out in an effort to control the disease. Liver Rot was responsible for quite serious losses among sheep during the spring. The developmental stage of the parasites found on post-mortem pointed to a continuous infestation well into the late autumn and in a number of instances large doses of carbon tetrachloride were considered advisable. A disease not formerly encountered in the Province, namely, Pig Pox, has been of fairly widespread occurrence during the year.

Investigational.

(*a*) *Pregnancy Toxaemia.* The incidence of this disease was remarkably low during the past year even on farms where losses during the previous year had been heavy. Further information was collected, but no specimens to provide samples of blood were available.

(*b*) *Swayback.* One serious and two minor outbreaks of this condition in lambs were encountered in the spring. It is hoped that the effect of providing a supply of copper to the ewes during pregnancy may be studied in the next lambing season.

Lectures.

A course of twelve lectures on Veterinary Science was given at the Somerset Farm Institute. In addition, twenty lectures were given to Young Farmers' Clubs and various branches of the National Farmers' Union in the Province.

POULTRY PATHOLOGY.

As in previous years progress can be reported in the number of specimens received for post-mortem examination and the number of requests for advice, the former totalling 1,762 and the latter 160.

Blood samples for the agglutination test, however, decreased in numbers to 85,044, the decrease being due to adverse economic conditions in the industry and provision by certain laboratories of cheaper rates for testing.

In assisting the Veterinary Investigation Officer, 88 visits were made to poultry farms in the Province, mainly with the object of assisting County Poultry Instructors and Veterinary Surgeons to deal with obscure or persistent mortality amongst poultry flocks.

Parasitic diseases are widespread, and appear to be due mainly to excessively low resistance of the stock. Overcrowding of land and too frequent use of the same areas are secondary factors.

In some instances, doubt has been experienced that slugs and snails have been the only intermediate host of the tapeworm *Davainia proglottina*, and there seems to be a possibility that certain insects are capable of acting in this capacity.

No satisfactory means have been found of dealing with Neuro-lymphomatosis (Fowl Paralysis) which is increasingly prevalent on certain farms.

Sporadic outbreaks of highly infectious diseases continue to occur; infectious laryngo-tracheitis was diagnosed on three occasions on farms in Wiltshire and two outbreaks of Fowl Cholera occurred in Worcestershire.

No treatment is recommended for either disease owing to the highly infectious character of each, and the tendency for carriers, *i.e.* infected birds showing no symptoms, to occur in the survivors.

Fowl Typhoid appeared on two farms, one in Somerset and one in Gloucester.

Tuberculosis caused heavy losses and unprofitable flocks in birds over two years old.

Amongst chickens, mismanagement (chilling, overheating and faulty feeding), Pullorum disease (Bacillary White Diarrhoea) and *caecal coccidiosis*, in that order of frequency have been responsible for the majority of losses.

Several instances of high mortality of young chicks, simulating Pullorum disease, were observed, and the organism isolated in six outbreaks was identified as *B. typhi-murium.*

Rickets and leg weaknesses of chicks have been more prevalent.

County Egg-Laying Trials.

The Poultry Pathologist was present at the reception of the birds at the County Egg-Laying Trials in Gloucestershire, Wiltshire and Somerset, and examined all birds entered for health and freedom from infectious disease.

Lectures.

A course of eight lectures on poultry diseases was delivered to the students of poultry husbandry at the Somerset Farm Institute.

In addition, one lecture on poultry diseases was given to an outside body under the Extension Lecture Scheme of the Ministry.

CIDER.

The number of enquiries received was 521, including 207 under the Cider Instruction Scheme, in which the counties of Dorset, Monmouth and Worcester participated. The total shows a decrease of 92 compared with the previous year which appears to be due to a falling off of requests for advice from the Eastern Counties relating to problems of utilising commercial varieties for cider-making. As usual, a number of enquiries came from abroad, including Australia, Egypt, Ireland, India, New Zealand, France and the U.S.A.

Approximately half the number of enquiries were of a general nature, concerning cider-making processes and farm-orcharding, while the remaining half were technical in character. There was an increase in the number of applications relating to the value of varieties of apples for cider, and this involved reports on a large number of fruit samples.

The enquiries concerning technical details of cider-making were received chiefly from commercial cider makers. The summer of 1936 was notable for the incidence of a number of cases of diseases of cider, which included sickness and ropiness. The enquiries came from various areas, and the suppression of the different diseases was only achieved after an examination of the individual problems and taking suitable precautions in regard to the sterilisation of vats and plant.

A feature of the year's advisory enquiries was the number of requests for information of a purely chemical nature. These included the determination of the "absolute" tannin content of cider, the removal of nitrogenous compounds by means of enzymes or chemicals, the evaluation of pectinous material in juices, ciders and dried apple pomace, and the determination of volatile acidity in ciders.

The Cider Instructor paid 145 visits to farms, 58 in Dorset, 25 in Monmouth and 62 in Worcestershire, relative to problems of cider-making and cider-orcharding.

In connection with the enquiries received from these counties, reports were made on 59 ciders and 25 analyses of ciders were involved. Sixty-five samples of apples and pears were received for identification and report on quality.

In Dorset, special attention was paid to the northern parts of the county, and demonstrations were given for the first time in the Sherborne district. In West Dorset there was a large increase in the quantity of cider made and sales appeared to be brisk. A survey of cider orchards in the county was begun, and this has already shown that a very large proportion of second-rate cider varieties occur in the orchards and that there is urgent need for the planting of new orchards to replace the old ones which are deteriorating rapidly.

Most of the work in Monmouth has been done in co-operation with the County Horticultural Staff. The Cider Department at Usk is under the Instructor's supervision. Many farm cider makers have taken advantage of the facilities at Usk for making and filtering their cider. Much time has been given to farm-orcharding problems.

In Worcester, a heavy cider apple crop led to considerable quantities of cider being made by farmers. Enquiries were received regarding up-to-date cider machinery and a modern plant was installed at Broadway which is available to local growers for milling and pressing at a fixed rate per ton.

The Instructor has been in close touch with the County Horticultural Instructor regarding orchard problems, and special attention has been given to the County Trial Orchards.

FRUIT PRODUCTS.

The year 1935-36 witnessed remarkable developments in the advisory work in this subject due to the commercial application of results of researches at Long Ashton, and it was not anticipated that the enquiries would be maintained at the high level of that year in 1936-37. Actually there was a slight increase in the number of enquiries, the record total of 661 being reached.

The wide interest in the work in Fruit Products is demonstrated by the sources of enquiries, 559, coming from outside the Bristol Province. These included the following: Cambridge (21), Devon (23), Essex (15), Kent (16), Suffolk (12), Sussex (31), Scotland (22), Australia (7), Canada (4), New Zealand (10), South Africa (2), Eire (6), India (9), Egypt (2), Kenya (3), Uganda (2), Rhodesia (2), New Guinea (1), British Honduras (1), Nigeria (2); Montserrat, Argentine, Bolivia, Denmark and Estonia (1), Latvia (3), Sweden (3), Switzerland (3), and U.S.A. (9).

There was a noticeable tendency throughout the year for the nature of the enquiries to become more technical and less general in their scope, and for this reason they usually entailed analytical determinations and in some cases extensive experimental work. It should also be noted that the enquiries often called for immediate action, especially when they concerned problems of processing fresh juices.

The numbers of visitors received at Long Ashton showed a large increase on the previous year, the total being 178. A large proportion of these were technical representatives of firms, and there were also a considerable number of horticultural officers from the Dominions, Colonies and Protectorates and from foreign countries. Whilst it is very satisfactory to deal with enquiries by personal visits in this way, it must be realised that the large number of visitors seriously affects the routine of the investigational work.

The close collaboration with Messrs. H. W. Carter & Co., Ltd., Bristol, was continued by special arrangement and the Products Officer again supervised the season's production of juices and syrups. Special attention was given to the production of syrups without the preliminary treatment of slight fermentation previously considered essential and a method was evolved by which this operation is omitted. A report on this work appears elsewhere in this Report (p. 191).

In addition to supervising production at Messrs. Carter's, the Products Officer was concerned with several other important commercial developments including the following :—

New Products. A firm of co-operative fruit growers was assisted in beginning the manufacture of cider vinegar.

Apple Juice. Experimental work in the canning of this product was carried out in collaboration with the Metal Box Company.

Syrups for Milk Bars. Methods for preventing curdling of hot milk shakes when pure fruit syrups are used were determined. The Products Officer also co-operated with the Milk Marketing Board and the National Milk Publicity Council in assessing flavour and chemical features of fruit syrups.

National Mark Aerated Juices. Bottlers who joined the tentative scheme were assisted with any problems which arose. Twenty-two firms were helped in this way.

Whey Powders. Attempts were made to utilise these with fruit syrups.

Orange Squashes. Oranges from India were tested for use as squashes, in collaboration with the Director of Developments of the N.W. Frontier of India.

Chocolate Centres. Tests were made with firms of chocolate manufacturers to determine the use of fruit syrups as " fillings."

Exhibits dealing with Fruit Products were staged at the Norfolk Show and the Imperial Fruit Show (Liverpool), and at the latter arrangements were made for the sale of pure fruit syrups on the Great Britain Stand.

POMOLOGY.

661 enquiries were received, of which 239 came from sources outside the Bristol Province. The total shows an increase of 37 over the previous year.

The usual proportion of enquiries came from overseas, mainly from Australia, New Zealand and South Africa.

The enquiries covered a very wide field. Requests relating to strawberry growing and the establishment of new fruit plantations were again numerous and, as usual, a large number of fruits, mainly apples, were received for identification.

Fifty-five advisory visits were paid to commercial fruit farms.

The number of visitors was again very large, a total of 138 being received by the pomological staff. In addition, the pomologists dealt with a large number of organised parties.

HORTICULTURAL CHEMISTRY.

118 enquiries, including 46 from outside the Province, were received. Overseas enquiries were received from Australia, India, New Zealand, South Africa, Argentine and Holland.

As in previous years the majority of requests concerned nutritional problems of fruit trees and garden and glasshouse crops.

There was an unusually large number of enquiries from allotment holders in the Bristol district, arising from crop failures.

The wet winter of 1936–37 appeared responsible for several failures of fruit crops, especially strawberries and raspberries, and seemed to be the cause of several cases of blotching and discoloration of apple foliage.

A number of fruit growers with newly-installed gas stores kept in close touch with the Station in connection with the condition of their fruit during the storage period and with various fruit " breakdowns " which occurred in the stores.

Considerable interest was shown during the year in methods of composting vegetable refuse, especially the Indore process.

Special Investigations in Progress.

1. *Experiments on the Control of Lime-induced Chlorosis in Apples, Pears and Plums—in Somerset and Worcestershire.*

Injections with ferric citrate were repeated at various centres, the old rates being increased. Striking responses were obtained. The duration of the effects will be recorded over a number of seasons.

2. *Manurial Experiments on Apples and Black Currants in Gloucestershire and Herefordshire.* In the experiment on black currants it has been shown that heavy fertiliser dressings are relatively ineffective in restoring fertility where humus supplies have been depleted by cultivation on an old orchard site. The effects of grassing down will be tested.

Good results continue from potash dressings in the experiment on Cox's Orange Pippin apple trees.

3. *Manurial Experiments on Asparagus—in Worcestershire.* Experiments were continued at Perdiswell and Sedgeberrow. The manures do not show any observable effects after two cutting seasons and growth remains excellent on all plots. Two growers' meetings were organised to inspect the Sedgeberrow plots, and efforts are being made to encourage annual meetings of local growers to keep them in touch with the experiments.

4. *Survey of Soils on the Lower Lias Formation.* Mapping has been continued in the Somerset area. The total area mapped is approximately 100 square miles.

Arrangements have been made with the Ministry of Agriculture and Fisheries for the publication of two bulletins on the survey work in the Vale of Evesham, viz.: (1) A Survey of the Soils of Evesham Vale. (2) Soils and Fruit Growing in the Evesham Vale.

ECONOMIC ENTOMOLOGY.

The number of enquiries received was 616. The main subjects of enquiry related to the following:—Fruit Tree Red Spider, Plum Sawfly, Apple Tortrix Moths, Apple Blossom Weevil, Flea Beetles, Cabbage Aphis, Cabbage White Fly. Numerous requests were received for spray programmes for fruit crops.

Spray Programme Service.

Spray programmes for the control of Plum Sawfly, Apple Sawfly, Red Spider, Raspberry Beetle and Codling Moth were prepared at appropriate times for the use of fruit growers. The information was distributed in various ways by the county agricultural authorities. Requests for these programmes were received from counties outside the Bristol Province.

Investigations in Progress.

Winter Washes.

1. Field and laboratory work was continued on the uses of the organic thiocyanates as means of controlling Aphides, Apple Sucker, Winter Moth, Red Spider and Capsids. A combined winter wash of certain of the thiocyanates and spindle oil provided high control of Aphides, Sucker and Red Spider. Further data are required on the control of Winter Moth and the Capsids.

2. The value of winter washes for the control, in particular, of Aphides and Red Spider on cider trees is under investigation. Three more seasons will be necessary to obtain reliable data.

Combined Summer Washes.

The experimental work on combined washes was continued. It was shown in preliminary experiments that solvent and acid refined petroleum oils of the same specification have similar phytocidal properties.

Laboratory Evaluation of Insecticides.

A considerable portion of the year's work was given to investigations on methods of laboratory evaluation of insecticides. Particular attention was paid to means of employing certain of the major insect pests of fruit as test subjects.

Plum Sawfly.

A field trial showed that a correctly timed single application of a combined wash of petroleum oil emulsion and *Lonchocarpus* ground root provided a commercial control of Plum Sawfly.

Red Spider.

Laboratory and field experiments which had been in progress for a number of years were completed. The acaricidal value of petroleum oils, lime-sulphur and rotenone containing preparations have been fully investigated.

Atomisation of Insecticides.

The experiments commenced in 1932 on the uses of atomised insecticides were continued. It was evident from preliminary field work that the complex nature of the problem necessitated detailed investigations and laboratory work was begun. Preliminary trials suggest that atomisation has a wide application for the control of pests under indoor conditions, but is of limited use on field crops.

Treatment of Nursery Stock.

Investigations were continued on dipping treatments for nursery stock in the dormant condition to ensure their freedom from pests before planting out.

The Control of Pea and Potato, "Sickness" due to *Heterodera Schachtii.*

This work was continued in collaboration with the Advisory Mycologist. Pot experiments were carried out with peas in a "sick" soil to examine the effect of fertiliser treatments on plant growth and eelworm population. The results suggest, as in the 1936 experiments, that eelworm infestation interferes with the nitrogen metabolism of the plants. The addition of nitrogen had no effect on eelworm infestation but enabled plants to obtain normal supplies of the element. The application of fairly normal dressings of nitrogenous fertilisers thus appears a practical method of obtaining normal crops in eelworm infested soil.

Control of the Granary Weevil *(Calandra granaria).*

Serious infestations in farm granaries where fumigation methods cannot be applied are being dealt with by the use of pyrethrum emulsions applied as sprays. The results obtained are distinctly encouraging, but protracted observations will be necessary before the efficiency of the treatment can be finally assessed.

The Control of the Cabbage Aphis *(Brevicoryne brassicae)* and Cabbage White Fly *(Aleurodes brassicae).*

These are the most serious of all the brassicae pests, and have caused particularly heavy losses in the Evesham district.

A lauryl rhodanate spray applied in autumn gave a good control of aphides but only moderate results with White Fly. Trials of winter applications, as an ovicide, have been hampered by absence or paucity of oviposition.

Pyrethrum-oil emulsions have given good results.

The Control of the Cabbage Root Maggot *(Hylemyia brassicae)* by the use of Calomel.

Extensive field trials during 1937 were nullified due to lack of infestation, and will be repeated during 1938.

Investigations on the Bionomics of the Mite *Tarsonemus Spirifex.*

This mite caused serious injuries to oats in 1912 and in 1937. Cases have now occurred in Gloucester, Somerset and Wiltshire. Until further information has been gained regarding the life history, wild hosts, etc., specific control measures cannot be given.

ECONOMIC MYCOLOGY.

496 enquiries were received, compared with 490 in the previous year.

The Adviser gave, for the first time, a course of lectures on Economic Mycology to Botany Students at Bristol University. The course is run concurrently with one on Economic Entomology, the two together comprising Plant Pathology. It consists of two lectures of one hour each and four hours of practical work every week in the autumn and spring terms, and tuition in practical and field work in the summer term. Most of the diseases of economic crops in England were dealt with, the lectures being illustrated by the very extensive collection of preserved (exhibit) material, coloured photographs, lantern slides and practical class material assembled by the Adviser.

The following report gives a brief summary of the more important investigations in hand during the period.

Fruit.

Apple Fruit Spots and Fruit Rots.

This subject has been taken over by E. H. Wilkinson, a post-graduate student, who is studying apple fruit spotting in relation to variety, manurial treatment of the tree, shape and maturity of the fruits, methods of picking, type of storage, etc., to the number and condition of the lenticels, and to the presence of causative fungi on the branch system of the tree.

Vegetables.

A full account of investigations on Vegetable Diseases under "Progress Report on Vegetable Diseases—IX" appears in this Report, p. 96.

Ornamentals.

Begonia.

A bacterial disease of winter-flowering begonias, which causes much loss to growers of these plants, is being examined in co-operation with W. J. Dowson and W. C. Moore.

Hyacinth.

A soft rot of "treated" hyacinths occurred in many greenhouses in the area. The organisms had usually entered the bulbs at the base of the scales and the disease was evidently associated with damage resulting from unusual ripening or storage conditions.

Lilies.

As a member of the R.H.S. Lily Committee and the Lily Research Sub-Committee, the Adviser is interested in lily diseases. Experiments were carried out with bulbs supplied by the Bermuda Department of Agriculture on the effects of the subjection of the bulbs to high and low temperatures and of deep and shallow planting. The results are published in the Lily Year Book for 1937.

Miscellaneous.

Seed Protectants.

J. G. Horsfall, of Geneva (N.Y.) Experiment Station, U.S.A., has introduced in that country the use of cuprous oxide and zinc oxide as seed protectants. During his visit to Long Ashton in the winter of 1936–37, the opportunity was taken of experimenting with these substances under English conditions, and this work has been extended by numerous greenhouse and field trials. A preliminary report appeared in the Gardeners' Chronicle for January 29th, 1938.

Fusarium Diseases.

Investigations on *Fusarium* diseases have been continued by D. L. G. Davies, a post-graduate worker. The diseases mainly studied have been a wilt of runner beans caused by *Fusarium vasinfectum* var. *lutulatum*, a foot rot of leeks caused by *Fusarium culmorum*, and pea foot rot, caused by *Fusarium Solani* var. *Martii* forma 2.

INSECTICIDES AND FUNGICIDES.

The enquiries received by post during the year totalled 156, of which 131 were from areas outside the Bristol Province, including 13 from overseas.

One-quarter of the enquiries concerned oil washes, other prominent subjects being combined washes, copper fungicides and organic thiocyanates. Interviews were given on 51 occasions to growers, and to representatives of 22 different commercial firms. In this way and by telephone, at least 350 verbal enquiries were answered.

In connection with the enquiries, 45 samples of spray materials were examined. The products analysed included 17 petroleum oils submitted by refiners for opinions concerning their suitability as stock oils for foliage spray preparations, 8 copper preparations intended for trial as fungicides and 16 tar oil or tar-petroleum oil preparations sent in by growers for the assessment of their probable value as winter washes. Three of the latter products, although recommended by the manufacturers for fruit tree application, were found unsuitable, two apparently being disinfectant fluids, the third, too unstable on storage for recommendation. The respective manufacturers were notified and in two cases satisfactory changes in composition have been made.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

94 enquiries were received, showing an increase of 34 over the previous year. 81 of the requests were from areas outside the Province.

In addition to the above enquiries, 138 special enquiries were received as the result of a broadcast given from the West Regional on January 14th.

Many of the enquiries came from officers of County Agricultural Departments. Thirty counties in England and Wales were represented, whilst thirteen of the enquiries were from abroad, Ireland (6), Scotland (3), Australia and Channel Islands (1), U.S.A. (2). Numerous visitors were received, including several from overseas.

The largest number of enquiries related to vegetable bottling. Other subjects of enquiry were as follows : jam, jelly and marmalade making ; sugarless jam for diabetics ; fruit syrups ; preservation of fruit in SO_2 ; bottling and canning of fruits ; mushroom canning ; pickling of walnuts, onions, etc. ; herbs ; literature of fruit preservation ; equipment, etc., for fruit preservation.

Lectures and Demonstrations.

These were held at the following centres : Gloucester ; Potton Estate, Bedfordshire : various centres in Derbyshire and at Derby ; Nottingham.

Courses of Instruction.

Three courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, from July to September, at which 45 students attended.

General.

The Instructress acted as a judge at the following produce shows : the Royal Show, Wolverhampton ; British Dairy Farmers' Show, London ; County Federation of Women's Institutes Exhibitions at Norwich, Nottingham, Aylesbury, Derby, Preston and Canterbury.

Close co-operation was maintained with the National Federation of Women's Institutes and the Instructress continued to serve on the Agricultural and Rural Domestic Economy Sub-Committee of the National Federation of Women's Institutes and the Rural Domestic Economy Sub-Committee of the Gloucestershire Federation of Women's Institutes.

WILLOW GROWING.

219 enquiries were answered, and of these 150 were from areas outside the Province.

40 visits were paid for land inspection with a view to willow growing.

The chief subjects of enquiry related to the suitability of land for willow growing, varieties, pest control, cultural treatment, the marketing of rods and the management of the Cricket Bat Willow tree.

21 enquiries concerned the treatment of old beds which had been neglected. These called for varying treatment according to circumstances. Grubbing is generally too costly, but weeds may sometimes be smothered by allowing the tops to grow without cutting for two or three years, and in others Cricket Bat Willows may be established by interplanting at intervals from 24ft. to 30ft.

Of the insect pests and fungus diseases on which advice is sought, all can usually be controlled with the exception of the "Button Top" midge.

Cricket Bat Willow enquiries numbered 198, and emanated chiefly from estates.

In advising on planting bat willows the Adviser emphasises two points: to plant only on suitable land and to plant rooted trees grown under well-managed nursery conditions, since it is important to produce only first grade timber.

An address and demonstration on problems of Cricket Bat Willow growing were given at the Annual Meeting of the English Forestry Society.

PUBLICATIONS, 1937.

LONG ASHTON RESEARCH STATION.

Annual Report of the Agricultural and Horticultural Research Station in the Bath and West Journal, 1936–37.

Barker, B. T. P.

"Cider Apple Production." (Bulletin No. 104 of Ministry of Agriculture and Fisheries, 75 pp. Published by H.M. Stationery Office, Adastral House, Kingsway, London, June 1937).

Charley, Vernon L. S.

"Fruit Requirements for the Cider Industry." (Scientific Horticulture, Vol. IV, pp. 57–67, 1936).

"Laboratory Methods in Fruit Products Research." (Chemical Age, pp. 357–359, April 1937).

"Fruit Juices and Syrups." (Journal of the Society of Chemical Industry, pp. 608–615, July 5th, 1937).

Fajans, E. and Martin, H.

"The Incorporation of Direct with Protective Insecticides and Fungicides. II. The Effects of Spray Supplement on the Retention and Tenacity of Protective Deposits." (Journ. of Pomol. and Hort. Sci., Vol. XV, No. 1, pp. 1–24, April 1937).

Horsfall, J. G., Marsh, R. W. and Martin, H.

"Studies upon the Copper Fungicides. IV. The Fungicidal Value of the Copper Oxides." (Annals of Applied Biology, Vol. XXIV, pp. 867–882, 1937).

Kearns, H. G. H.

"The Control of Plum Sawfly (Hoplocampa flava, L.)" (Worcestershire County Council Agricultural Quarterly Chronicle, Vol. 5, No. 3, pp. 137–145, 1937).

Kearns, H. G. H., Martin, H. and Wilkins, A.

"Investigations on Egg-Killing Washes. II. The Ovicidal Properties of Hydrocarbon Oils on *Aphis pomi*, de Geer." (Journ. of Pomol. and Hort. Sci., Vol. XV, No. 1, pp. 56–68, April 1937).

Marsh, R. W.

"Notes on Apple Canker." (Bath and West Journal, Vol. XI, pp. 42–47, 1936–37.)

"Some Recent American Work on the Copper Fungicides." (Scientific Horticulture, Vol. V, pp. 60–66, 1937).

Marsh, R. W., Martin, H. and Munson, R. G.

"Studies upon the Copper Fungicides. III. The Distribution of Fungicidal Properties among certain Copper Compounds." (Annals of Applied Biology, Vol. XXIV, pp. 853-866, 1937).

Martin, H.

"Detergents and Wetting-out Agents as Assistants in Plant Pest Control. Wetting and Detergency: Scientific and Technical Aspects." (Publisher, A. Harvey, London, pp. 117–135, 1937).

Ogilvie, L., Hickman, C. J. and Hobbis, E. W.

"Winter Lettuce Trials." (Worcs. County Council Agricultural Quarterly Chronicle, Vol. 5, No. 4, pp. 201–213, August 1937).

Ogilvie, L.

"The St. Helena Lily: *Lilium longiflorum* var." (Gardeners' Chronicle, p. 320, Oct. 30th, 1937).

"Some Experiments with Lilies." (R.H.S. Lily Year Book, p. 106, 1937).

"The Lily Mosaic Virus." (R.H.S. Lily Year Book, p. 140, 1937).

Wallace, T.

"Manuring of Fruit Crops." (Bulletin No. 107, Ministry of Agriculture and Fisheries, 47 pp. Publishers, His Majesty's Stationery Office, Adastral House, Kingsway, London, June 1937).

Wallace, T. and Osmond, D. A. (With Gaut, R. C. and Hobbis, E. W.).

"Raspberry Manurial Trials at Perdiswell." (Worcestershire County Council Agricultural Quarterly Chronicle, Vol. 6, No. 1, pp. 9–31, Nov. 1937).

Walton, C. L.

"The Economic Status of *Elachiptera cornuta*, Fall." (Entomologists' Monthly Magazine, pp. 65–66, March 1937).

"The Cause of 'Spotting' of Tomato Fruits (Stigmonose)." (The Gardeners' Chronicle, No. 2610, Vol. CI, pp. 12–14, Jan. 2nd, 1937).

BERKELEY SQUARE ADVISORY CENTRE.

Dawe, C. V.

"Farming in 1937: A Review of the Year." (Farmers Weekly, Vol. VII, No. 27, p. 23, Dec. 31st, 1937).

"Labour Shortage on the Dairy Farm." (Farmers Weekly, Vol. VII, No. 9, p. 23, Aug. 27th, 1937).

Dawe, C. V. and Hewett, L. J.

"Income and Expenditure on Thirty Mixed Farms in Wiltshire and Somerset." (Farm Economist, Vol. II, No. 6, pp. 93–94, April 1937).

Dawe, C. V. and Trist, P. J. O.

"Costs of Erecting Fattening Houses for Pigs." (Farm Economist, Vol. II, No. 5, pp. 80–82, Jan. 1937).

"A Survey of Pig Management." (University Bulletin, No. 17, February 1937).

"Factors which Influence Pig Profits." (Farmers Weekly, Vol. VI, No. 17, p. 48, April 1937).

"Why some Pig Farmers Lose Money." (Farmers Weekly, Vol. VII, No. 3, p. 23, July 16, 1937).

Dawe, C. V. and Wragg, S. R.

"Farmhouse Cheesemaking." (Farm Economist, Vol. II, No. 8, pp. 143–144, October 1937).

Ling, A. W.

"The Management and Manuring of Grassland and the Utilisation of Grass." (Somerset and North Dorset Milk Recording Association's Year Book, 1937).

"Agriculture in the West Country." (The Times, Trade and Engineering. Vol. XLI, No. 880 (New Series) pp. 3–4, June 1937).

"Poultry and the Land Fertility Scheme." (The Farmers Weekly, Vol. VII, No. 21, p. 43, Nov. 19th, 1937).

"Bath and West Society's Grassland Competition, 1937." (Wiltshire N.F.U. Record, Vol. 5, No. 12, pp 74–76, Dec. 1937).

Ling, A. W. and Muir, W. R.

"Some Observations on the Effect of Poultry on the Chemical Composition of Herbage and Soil." (Journal of the Ministry of Agriculture, Vol. LXIII, No. 11, pp. 1056–1067, Feb. 1937).

"The Effect of Poultry on the Chemical Composition of Herbage and Soil." (The Western Poultryman, Somerset Poultry Federation, Vol. IV, No. 3, pp. 25–28, June 1937).

Muir, W. R.

"The Effect of Poultry on the Chemical Composition of Herbage and Soil." (The Worcestershire Chronicle, Vol. 5, No. 1, pp. 175–180, March 1937).

"The Effect of Poultry on the Chemical Composition of Herbage and Soil." (The Herefordshire Journal, Vol. 5, No. 1, pp. 27–33, March 1937).

Watkins, H. T.

"Liming an Essential Factor in Soil Fertility." (The Herefordshire Agricultural Quarterly Journal, Vol. 5, No. 4, pp. 134–143, Dec. 1937).

CAMPDEN RESEARCH STATION.

ADAM, W. B.

"The Acidity and Hydrogen Ion Concentration of English Canned Fruits." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 51, 1935–36).

ADAM, W. B. and HORNER, G.

"The Tin Content of English Canned Fruits and Vegetables." (Journal Society of Chemical Industry, Vol. 56, 329T—333T, September 1937).

ADAM, W. B. and SIDDAPPA, G. S.

"The Composition and Texture of Dried Peas." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 34, 1935–36).

ADAM, W. B. and STANWORTH, J.

"The Effect of Internal Pressures on the Volume of Cans." (Ibid., p. 62, 1935–36).

GILLESPY, T. G.

"A Study of the Growth of Mixed Organisms in Canned Vegetables." (Ibid., p. 21, 1935–36).

HIRST, F.

"Canning Trials on Plum Varieties." (Worcestershire Agricultural Chronicle, May 1937).

"Canned Foods in Relation to National Defence." (Journal of the Royal Institute of Public Health and Hygiene, December 1937).

HIRST, F. and ADAM, W. B.

"Hydrogen Swells in Canned Fruits." (Monograph, No. 1, Fruit and Vegetable Preservation Research Station, Campden, Glos., March 1937.

HORNER, G.

"Progress Report on the Mineral Content of Canned Vegetables." (Annual Report of the Fruit and Vegetable Preservation Research Station, Campden, Glos., p. 30, 1935–36).